DOCUMENT RESUME

ED 313 517 CE 053 679

TITLE New Technologies in the 1990s: A Socio-economic Strategy. Report of a Group of Experts on the Social Aspects of New Technologies.
INSTITUTION Organisation for Economic Cooperation and Development, Paris (France).
REPORT NO ISBN-92-64-13180-9
PUB DATE 88
NOTE 123p.; For a related document, see ED 303 140.
AVAILABLE FROM OECD Publications and Information Centre, 2001 L Street, NW, Suite 700, Washington, DC 20036-4095 ($21.00).
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Automation; Culture Lag; Developed Nations; Economic Factors; Economic Opportunities; Economic Progress; *Futures (of Society); Information Technology; Labor Force Development; Linking Agents; *Modernization; *Policy Formation; Productivity; Research and Development; Research Utilization; *Science and Society; Sociocultural Patterns; *Socioeconomic Influences; Structural Unemployment; Technological Advancement; Technological Literacy; *Technology Transfer

ABSTRACT

The world needs a socioeconomic strategy--a set of interrelated policies that recognize that social and institutional changes at all levels of society are necessary to realize fully the technical and economic potential of new technologies. An assessment and dissemination of how different countries in the Organisation for Economic Co-operation and Development (OECD) have successfully adjusted their institutions and labor market practices is also needed. Effective implementation of change requires management commitment to deepen the involvement of those affected by new products, processes, and systems. Technological change cannot be realized without changes in the education and training system to produce a more highly skilled and educated work force. Social innovations are required to translate technology-induced productivity gains into higher employment. Having all society members equipped for making a useful contribution to economic and social life should become an objective of public policy. An investment climate should be created in which decisions to augment physical capital accompany decisions to augment intangible capital. An expanding world market is necessary for the socioeconomic strategy to succeed. Technological innovation and social change must be seen as an integrated process and should be managed as such. Technological assessments should be developed and maintained on a continual basis in order to contribute to informed public debate. This report by a multinational group of experts examines the national and international implications of new technologies in five chapters which discuss, respectively, the new structural challenge, the impact on employment and productivity, workplace flexibility, human resource development, and effects on society as a whole. A bibliography containing 196 entries concludes the document. (CML)

ED313517

New Technologies in the 1990s

A Socio-economic Strategy

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL IN **MICROFICHE ONLY** HAS BEEN GRANTED BY

J R West

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

CE053679

OCDE
OECD

PARIS 1988

BEST COPY AVAILABLE

CE

New Technologies in the 1990s

A Socio-economic Strategy

Report of a Group of Experts
on the Social Aspects of New Technologies

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, the Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries acceded subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971) and New Zealand (29th May 1973).

The Socialist Federal Republic of Yugoslavia takes part in some of the work of the OECD (agreement of 28th October 1961).

Publié en français sous le titre:

NOUVELLES TECHNOLOGIES :
UNE STRATÉGIE SOCIO-ÉCONOMIQUE POUR LES ANNÉES 90

© OECD, 1988
Application for permission to reproduce or translate
all or part of this publication should be made to:
Head of Publications Service, OECD
2, rue André-Pascal, 75775 PARIS CEDEX 16, France.

TABLE OF CONTENTS

PREFACE 5

LETTER OF TRANSMITTAL 7

CONCLUSIONS AND RECOMMENDATIONS 9

ANALYTICAL REPORT

Introduction 29

Chapter 1. THE NEW STRUCTURAL CHALLENGE

- A. A Taxonomy of Technical Change 33
- B. The Major New Technologies 35
- C. Information Technology (IT): The Main Characteristics 37
- D. The Pervasiveness of IT 40
- E. Conclusions 43
- Bibliography 44

Chapter 2. EMPLOYMENT AND PRODUCTIVITY

- A. Introduction 45
- B. Technological Change and Productivity Growth 47
- C. Productivity Growth and Employment Performance 58
- D. The Process of Adaptation: International and Regional Dimensions 60
- E. Conclusions 63
- Bibliography 64

Chapter 3. FLEXIBILITY IN THE WORKPLACE

- A. Introduction 67
- B. Information Technology and the Content of Work 67
- C. Work Organisation and the Utilisation of IT 75
- D. Information Technology and Industrial Relations 79
- E. Conclusions 87
- Bibliography 90

Chapter 4. HUMAN RESOURCE DEVELOPMENT

- A. Introduction 95
- B. Skill Development: Quantity 96
- C. Skill Development: Content and Quality 102
- D. Access to Skill 107
- E. Conclusions 110
- Bibliography 113

Chapter 5. NEW TECHNOLOGIES AND SOCIETY

A. Technology as a Social Process 117
B. The Social Integration of Technology 118
C. The Need for Social Innovation and Democratic Values 119
D. Social Risks and Costs 120
E. R&D Policy 122
F. Constructive Technology Assessment 123
G. Conclusions 124
Bibliography 126

PREFACE

High unemployment in OECD countries, especially in Europe, and its concentration among certain groups, has focused attention on the need for structural reforms. This need is reinforced by technological change which not only offers new potential for work opportunities but is, simultaneously, a key agent of structural change. Hence, the advent of several new technologies has been greeted by some as offering the panacea, while by some others as further complicating the process of adjustment. The variety of conflicting views expressed on the subject argues for careful analysis.

These considerations led the OECD Ministers of Labour, when they met in November 1986, to ask me to set up a Group of distinguished experts to examine "the great potential importance of the new technologies for growth, jobs and welfare", and to "report on their national and international implications both for employment and for our societies more generally". On their advice I set up the Group under the chairmanship of Mr. Ulf Sundqvist, Chief General Manager, Labour Savings Bank of Finland, former Minister of Education and former Minister of Industry, Finland. The members of this Group were people with wide experience in industry, labour relations, academia or public service. They served in their capacity as individuals: their Report does not commit OECD governments.

The Report examines a set of complex and controversial issues. It makes an important contribution in recognising the economic and welfare potential offered by the new technologies by stressing that technological change is a social process. If not accompanied by appropriate structural and institutional reforms together with a satisfactory rate of investment, it may fail to contribute to the extent it should to higher levels of jobs and welfare. In coming to policy conclusions the Report rightly takes into account economic as well as social and human factors, and pays attention to the increasingly interdependent nature of the global economy. It is especially noteworthy that the Group has produced a set of unanimously agreed recommendations, which call for action by a wider range of governmental and non-governmental groups, including policy-makers representing enterprises, business and labour organisations, and the authorities dealing with education, labour market, regional issues and international co-ordination.

The Report promises to be a valuable input to the OECD's continuing work on technological change and structural adjustment. I will be bringing it to the attention of Member governments. I believe that its analysis and recommendations will be found important and will be widely debated by policy-makers among business circles, trade unions, educationists and governments.

Jean-Claude Paye
Secretary-General of the OECD

Also available

INDUSTRIAL REVIVAL THROUGH TECHNOLOGY (1988)
(70 88 02 1) ISBN 92-64-13103-5 228 pages £12.00 US$22.00 F100.00 DM43.00

HUMAN RESOURCES AND CORPORATE STRATEGY: TECHNOLOGICAL CHANGE IN BANKS AND INSURANCE COMPANIES (1988)
(96 88 01 1) ISBN 92-64-13096-9 88 pages £8.50 US$15.50 F70.00 DM31.00

INFORMATION TECHNOLOGY AND NEW GROWTH OPPORTUNITIES (1988)
(93 88 05 1) ISBN 92-64-13102-7 226 pages (approx.) £12.00 US$22.00 F100.00 DM43.00

INFORMATION TECHNOLOGIES AND BASIC LEARNING: READING, WRITING, SCIENCE AND MATHEMATICS (1987)
(96 87 05 1) ISBN 92-64-13025-X 270 pages £15.00 US$32.00 F150.00 DM65.00

Prices charged at the OECD Bookshop.

THE OECD CATALOGUE OF PUBLICATIONS and supplements will be sent free of charge on request addressed either to OECD Publications Service, 2, rue André-Pascal, 75775 PARIS CEDEX 16, or to the OECD Distributor in your country.

Letter of Transmittal

Dear Mr. Paye,

Last July you set up a Group of distinguished experts, under my chairmanship, with the mandate to examine the national and international implications of the new technologies on employment and on societies more generally. It is with great pleasure that I herewith submit to you the Report of the Group*. I am happy to report that the Group has reached unanimity on the policy recommendations it makes.

I would like to thank the members of the Group for the varied and rich expertise and the wisdom they brought to bear on a set of extremely complex and controversial issues. Their diligence and co-operation made it possible to prepare a report of this magnitude in such a short time. Our efforts, it needs to be stressed, would not have succeeded without the competent and unfailing support we received from the Secretariat.

Ulf Sundqvist
Chairman
Group of Experts on the Social Aspects
of New Technologies

Helsinki, July 1988

---

* Other members of the Group were: Mr. Sigfried Bleicher (Board Member, I.G. Metal, Germany), Professor Renato Brunetta (University of Venice, Economic Advisor to the Minister of Labour, Italy), Mr. Frank Doyle (Senior Vice-President, General Electric, United States), Professor Chris Freeman (SPRU, University of Sussex, United Kingdom), Professor Jean-Jacques Salomon (Director, *Centre Science, Technologie et Société*, CNAM, France), Professor Haruo Shimada (Keio University, Japan) and Professor Luc Soete (Director, MERIT, University of Limburg, Netherlands). Mr. Abrar Hasan of the OECD Secretariat served as secretary to the Group.

CONCLUSIONS AND RECOMMENDATIONS

A. INTRODUCTION

Technological Change as a Social Process. The starting point of our Report is the interdependence of technical, economic and social change. Technological change is often equated either with certain hardware, or with specific production processes; this is a mistake. Technological change is, in its development and application, fundamentally a social process, not an event, and should be viewed not in static but in dynamic terms. That it is a social process is demonstrated by the useful distinction between pervasive technologies, such as the information technologies (IT), which have an impact throughout the economic system, and others, whose impact is principally on particular firms or individual sectors. Pervasive technologies cannot be imposed on our societies; they have to be introduced through institutional adaptation and a process which mediates between differences of interest.

The Importance of Wider Environmental and Societal Considerations. As living standards have improved in OECD Member countries, concern has grown about the quality of products and services, the quality of work, about environmental conservation and improvement, and the quality of life more generally. These issues require systematic consideration and public debate preferably in the form of institutional innovations such as "Technology Assessment". This is not to minimise the importance of productivity growth, which is essential, not least to ensure the availability of resources for environmental improvements.

Features of the Structural Break. We have concluded that information technologies represent a key structural break, and offer considerable productivity potential. We found the following arguments particularly persuasive. First, IT, based on a cluster of interrelated innovations in micro-electronics, computers and telecommunications, is an extraordinarily pervasive technology. Potentially it can be used in all sectors and in all functions; in factories and in offices, as well as in homes. Second, many studies suggest that productivity gains can be substantial, thanks to an unprecedented rapid decline in costs. Third, information technologies are the fruit of a rich collection of inventions, which means that R&D productivity is shifted on to a new and higher trajectory. Fourth, the productivity potential of IT is further enhanced when considered in conjunction with other technological developments, particularly in materials and bio-technology.

Emerging Disequilibria. These characteristics of IT generate various types of disequilibria, sometimes characterised as disequilibria "both in time and in space". These may arise within countries, and also between them. The pattern of job creation and job destruction will normally be unevenly distributed from one region, industry or occupation to another, and, if unchecked, may encourage dualism in society. The "virtuous circle" of innovation, growth and employment might be weakened if the transition costs during the process of job destruction and job creation turn out to be unacceptably high.

B. THE NEED FOR A SOCIO-ECONOMIC STRATEGY FOR NEW TECHNOLOGIES

The Importance of the Productivity Dividend. Technological change is one of the key determinants of long-term job growth and social progress. Historically, rising output in the industrialised countries has gone hand in hand with rising employment and growth of labour productivity, the latter attributable in large measure to technological change. Rates of unemployment tend to be high in periods of low productivity growth, such as the inter-war years and the 1970s, and low in periods of high productivity growth, such as the 1950s and 1960s. The productivity growth made possible by technological change is in the nature of a dividend, which can increase both profits and labour incomes. In the latter case, it can be distributed in the form of better wages, hours and working conditions. In other words, improvements in labour productivity permit sustained improvements in wages and working conditions as well as improvements in the quality of life and the availability of leisure over the long term.

Realising the Potential is not Automatic. That a technology has a potential is, however, only part of the story. To be socially relevant the potential must be translated into actual productivity gains, and thus into higher rates of output, earnings and employment. Puzzlingly, despite its productivity-enhancing potential, IT has been slower to enter some industrial sectors than expected, and has often failed to show up in measured growth rates of aggregate productivity. Far from diminishing the significance of IT, these paradoxes should be explained mainly in terms of the interdependence of technical, economic and institutional change. The factors responsible for the low take-up rates and the poor productivity performance need to be identified. The obstacles to realising the productivity potential also constrain the diffusion of these technologies. It is in these areas that the need for a strategy resides.

Objectives of a Strategy for New Technologies. In the economic and social context outlined above, policies would aim at sustained non-inflationary economic growth such that full-time or part-time work is available for all who actively seek it (the "active society"), and the emerging dualism in the labour market and society is avoided. This is a necessary pre-condition for attaining other social goals. Taking into account the increasingly interdependent nature of the global economy, the growth of OECD nations' needs is best achieved in concert with development elsewhere, so that a virtuous circle of economic and social growth is sustainable. Consistent with this, Member countries should adopt a long-term strategy of continuing innovation, both technical and social, in order to safeguard and strengthen their own growth potential as other (formerly Third World) countries catch up with the technological leaders in OECD. Furthermore, they need to take into account not merely the quantitative growth of per capita GNP, but also the wider environmental and societal issues involved with any major new technology.

Who is to Take Action. These objectives have shaped the strategy elaborated in this Report. The Report is forward-looking; it takes the 1990s as the reference point. It is based on emerging, rather than firmly established, trends. While the policy package it presents is mainly geared to governments, it emphasizes the role played by various groups in a democratic society. The recommendations it contains are, moreover, mutually supportive. Individual Member countries would undoubtedly each place different weight on the various components. The policy package therefore aims to exploit the high degree of interrelationship between the policies and actions of the various authorities and organisations, since efforts directed to achieving one target also help attain others.

RECOMMENDATION

We stress the need for a long-term socio-economic strategy for new technologies. By this we mean a set of interrelated policies which take into account that neither the technical, nor the economic, potential of major new technologies can be fully realised without concomitant, even anticipatory, social and institutional changes at all levels in society.

C. ELEMENTS OF THE STRATEGY

Continuing Innovation. The focal point of the proposed strategy is the generation and maintenance of advanced capacity for continuing innovation, both technical and social. Its two key requirements are advanced R & D capacity, and social and institutional innovations to facilitate rapid diffusion. These requirements can be satisfactorily achieved only through a high rate of investment, both physical and intangible, and a socio-economic environment favourable to change. Investment is crucial, since it is via this mechanism that new technologies become embodied and diffused. A high degree of confidence is necessary for the climate in which the necessary investment can take place and its productivity be realised.

New Rules of the Game. A climate of confidence for the successful introduction of new technologies requires what may be described as "the comprehensive innovation process" – innovation in a broad range of activities and processes. The spectrum includes not only the enterprise and the market, but also the rules of the game as set by society through its various organs. Hence, entrepreneurship, management, work organisation, financing, the opening up of markets, worker and employer organisations, labour market, educational and regional authorities, etc., are all involved. We believe that the more radical the nature of technological change, the more profound and complex the social interaction it generates, and the more innovative institutional changes it necessitates. A good example is in the whole sphere of new information services and networks based on telecommunications and computerised data banks. Without these services the productivity benefits of the new technologies are unlikely to be satisfactorily realised. It is sometimes forgotten that markets are themselves social institutions operating within a specific legal framework, requiring standards and norms as well as tacit and implicit behavioural rules to give confidence for new investment.

New Rules and the Role of Market Forces. In this perspective, the role that markets play can be crucial: they are best suited to the allocation of resources and the picking of winners in the short term and medium term. However, markets work best when the rules of the game under which they operate are appropriate. The introduction of radical new technologies necessitates changes in the rules of the game and other long-term allocative mechanisms. While market pressures can help, they are not sufficient to bring about the required changes.

A smoothly functioning market is a necessary, but not a sufficient, condition for accelerating the pace of diffusion and achieving the desired distributional effects; institutional innovations provide the necessary complement.

Important Choices. Important choices have to be made, because institutional and attitudinal changes are not easy to accomplish. Some of these choices may be more acceptable than others, and this Report is directed to examining them. While important conflicts of interest may precede and accompany technical change, its introduction can confer benefits on all parties. Different societies have gone about adjusting to the new technologies in a variety of ways, and with markedly different effects. The assessment of the successful cases and of their potential application in different institutional set-ups could be an important role for international organisations. The international dissemination of best-practice productivity is an important aspect of the sustained growth of the global economy, as was particularly evident in the recovery and rapid growth of the OECD economies after the Second World War.

RECOMMENDATION

Since the international dissemination of best-practice productivity is an important means to achieve sustained and balanced growth of the global economy, we recommend a careful assessment of how different OECD economies have successfully adjusted their institutions and labour market practices to new technologies, with a view to stimulating similar adjustments in countries with a different institutional set-up. A comprehensive statistical data base needs to be developed for the assessment. The idea of an OECD-based Productivity Movement should be revived, to instigate an international learning process about best-practice application and diffusion of new technologies, taking into account the specific characteristics of these technologies.

D. FLEXIBILITY IN THE ENTERPRISE

The Micro Level is Decisive. The performance of any socio-economic system depends ultimately upon the capability of management and workers at the enterprise level. The full exploitation of the new technologies implies a shift from the "Tayloristic" model of production organisation which dominated the first half of the century, not only in manufacturing but also in the services and public administration, to a much more decentralised organisational structure which emphasizes a two-way flow of information. Traditionally, efficiency and control were the twin objectives of management, but two new features have been introduced with the advent of the new technologies. First, the high cost of some of the new equipment means that incomplete or poor use can be extremely costly. Second, short commercialisation cycles and the associated tendency towards shorter production cycles mean that the enterprise has to be more responsive to emerging markets. Considerable advantage can be gained here through greater worker participation. The key to achieving this is commitment of management to establish close working relationships between managers, engineers and workers. New technologies can help to broaden the area of mutual interest in enhanced responsibility and involvement of workers. At the same time they offer a wider choice in decentralising the management, production, marketing and design process.

Big Changes in Occupations and Skills. The requirement of changes in management thinking has important implications for organisational and skill structures. From a typical pyramid-shaped structure the move is towards a substantial upgrading and broadening of skills. Narrowly defined job categories have to be replaced by broader job classifications, so that workers are provided incentives in the form of on-the-job learning opportunities. Payments linked to individual competences, rather than to output, and to the performance of the enterprise as a whole can provide incentives for workers to acquire new skills and thus help encourage redeployment and job redesign.

New Patterns of Working Time and Worker Involvement. There are other areas too of mutuality of interest between managers and the workers. New arrangements can be devised whereby work schedules both correspond to the aspirations of the labour force and make intensive use of expensive capital equipment. The basic approach requires managers, workers, and their representatives at enterprise level to confer in the early stages of introducing new technology; superficial participation or bureaucratic forms should be avoided. The realisation is dawning that this can be in the interest of all, even in the early stages of design and development.

A Changing Pattern of Union and Business Organisation. To achieve the hoped-for results, both workers' and employers' organisations will need to review their traditional structures. Unions may have to examine craft boundaries – as they already have in several countries – and perhaps modify their structures to ensure that, while solidarity of interests is maintained, there is no serious impediment to the adoption of new technologies. Employers should look beyond the collective bargaining, whether in the enterprise or in the industrial context, and foster new regional approaches as well as collaborative arrangements with other enterprises and public institutions in such areas as research, training and communication networks.

RECOMMENDATION

In enterprises and other productive organisations, the effective implementation of technological change requires a strong commitment by management to deepen the involvement of those affected by new products, processes and systems. Broadly speaking this means in many instances a shift from "Tayloristic" patterns of organisation, with their fragmentation of work tasks and layers of supervising management, towards multi-skilling and the devolution of responsibility. Such change will require the retraining both of managers and of workers. It also means a trend towards the "horizontal" integration of departmental functions within the enterprise, and the interchange of information throughout the enterprise, from the earliest stages.

E. A RESPONSIVE EDUCATION SYSTEM

The Need for Flexibility and a Broad-Based Education. We insist on the crucial supportive role of the education system. Action is indicated in several areas. The education system needs to provide workers with an adequate basis for the later acquisition of new skills, and to facilitate the movement of workers between industries, occupations and employers. This implies a more flexible response by the education authorities to the changing pattern of occupational skills, but above all a higher minimum threshold of competences for all young people if they are to compete in the fast-changing labour market. These competences provide the basis for long-term flexibility, and should be combined with subsequent training opportunities which facilitate transition into working life and provide an adequate supply of creative and highly qualified people. To achieve the necessary degree of responsiveness in the education system, teachers themselves have to be retrained. And major investments in higher education are needed to underwrite the needs of a high and rising R&D capacity of the economy and to sustain the essential base in fundamental research.

Changing Work Requirements. Education and training systems will increasingly be required to meet the demands of modern production processes. New technology tends to change work organisation and job content towards greater emphasis upon qualities like teamwork, initiative, creativity, entrepreneurship, problem-solving and openness to change. Many of these characteristics cannot be developed from scratch at the workplace but depend, to a large extent, on appropriate education and socialisation experienced particularly in schools.

Impact on Education Practice. New technologies, in particular the new information technologies, can free teachers from the constraints of time, space and large classes. They can cut costs and increase teachers' productivity. Education systems face the challenge of combining the best in traditional methods with the modern.

The Need for Enterprise-Level Training. There is a wide variety of training systems in OECD Member countries with different combinations of public and private provision. Smaller firms often lack the resources to organise training, but in general it is often advantageous for firms to complement the public system with their own specific training programmes designed to meet their own changing requirements. This helps foster good industrial relations and communication within the firm. OECD could perform a useful role in making good the lack of internationally comparable statistics.

Education and Training throughout Life. Adults seeking to requalify themselves for entirely different occupations cannot succeed without further training and education. This requires improved co-operation between education, enterprise and the trade unions. The reforms now being contemplated in Member countries should benefit from open dialogue between the educational establishment and all the parties that have a stake in educational outcomes, including the social partners as well as labour market and regional development authorities. An active society requires education and training throughout life.

RECOMMENDATION

Technological change cannot be realised without concomitant, even anticipatory, changes in the education and training system, to meet the requirement for a more highly skilled and educated workforce. It is necessary to develop more flexible types of course provisions, both within enterprises and in the higher education system. A broad general secondary and tertiary education for large numbers of young people needs to be complemented by more specialised adult courses throughout working life, sometimes in industry, sometimes in educational institutions, and sometimes in combined courses. Teachers will need frequent retraining. Educational methods and pedagogy should be further developed to foster initiative, creativity, and responsibility among young people in order to better prepare them for the new conditions at work. These efforts will carry considerable costs. While there is a variety of financing practices in Member countries, we believe that, as a matter of principle, the employer – not just the State – should carry a major responsibility for retraining workers to enable them to use new equipment and procedures.

F. CREATING MORE OPPORTUNITIES: THE ACTIVE SOCIETY

The Notion of the Active Society. The post-war period of strong economic growth permitted the building of the welfare state on a solid basis of full employment. An economically active part of the population was able to generate the necessary resources to finance rising standards of well-being for all, both the economically active and the non-active. Large-scale and persistent unemployment, with the ensuing costs to society of unused human resources, social stigma and decaying skills, have raised fundamental questions about social organisation, the role of the individual in society, and society's responsibility to the individual. The post-war model is likely to be put under further pressure by the ageing of populations. A third challenge could be a change of individual preferences away from contentment with income support, towards active involvement in the productive system. A new model should therefore be considered: an "active society", in which policies are designed to help as many people as possible to play a positive role, in which they can perceive themselves and be perceived as making a useful contribution to economic and social life. Paid employment in the market would still be the principal form of contribution, but it could take new and more varied forms. The new technologies, with their fundamental impact on the world of work, will facilitate this change if their introduction is accompanied by changes in work organisation, new working time arrangements, and new opportunities for education and training.

New Patterns of Work. These considerations suggest the need for a new concept of full employment. Full employment cannot realistically mean a 40-hour work week (or a 35-hour work week) for everyone up to the age of 60 or 65, and the exclusion or marginalisation of all others from this privileged group. It must rather be defined in terms of the right of people to make an active contribution to society at all times with a varied length of working week, working day and working year, depending upon their preferences, their family and life circumstances, their education and training. To achieve this, public policy will have to play an active role in creating new opportunities. Work fulfils many functions in addition to income maintenance: it provides dignity, social recognition, a focus for people's lives, meaningful social relationships and purposeful activity. Less-than-full-time work schedules can be desirable for the elderly, for mothers and fathers, for young people, indeed for all who wish to make an active contribution to society. However, the danger is that a dual labour market might relegate these part-time participants to an inferior status. To avoid this will require much imaginative thinking by employers, by unions and by public authorities, as well as changes in attitudes in society more generally. Among other things, new training opportunities should be available which can facilitate the mobility of workers between the varying roles which are now potentially available in the labour market.

Alternate Working Time Arrangements. Independently of changes in technology, demands have been growing from workers for more flexible working arrangements. This coincides with a growing demand for flexibility from employers, who wish to vary labour input in response to fluctuations in product demand, and from consumers, who wish for example to profit from non-restrictive shop hours. Recent experience has shown that the desires of the various actors are often difficult to reconcile, especially concerning weekly and annual working time arrangements. Nevertheless, the considerable capacity of the new technologies to increase the range of modes of production and forms of work organisation should encourage both sides of industry to carry on negotiations for appropriate arrangements, and should induce governments to support this process.

New Jobs in Services, Particularly the Information Sector. We have argued that many new full-and part-time jobs could be created by a wave of new investment associated with the worldwide diffusion of the new technologies. But this depends upon enhancing productivity growth, particularly in the service sector, and upon the generation of new types of service activity. We believe that when the new technologies are introduced in the service sector, they will generate a process described as a "reverse product cycle" whose culminating phase is characterised by product innovations through the generation of new types of services – services so different in nature and mode of delivery from more traditional forms that they can be described as new service products. These new types of service industries, based primarily on information, knowledge, and education sector activities have major job-generating potential. Examples can be found in home banking and shopping, network information services for domestic and business users, computer-aided education and training, and expert systems for medical diagnosis. New service sector jobs could also be created in response to extended leisure activities and alternative work schedules. Examples are the cultural sector, the preservation of nature and the environment, urban renewal and the maintenance and redeployment of the existing public infrastructure.

The Revitalisation of Traditional Industries and the Creation of Small Firms. There are already many examples of applications of information technology which have led to the survival or rejuvenation of old established industries. While the total number of jobs often had to be reduced, many jobs have been preserved, and job security improved. In order to minimise job losses, restructuring must be done as early as possible. As part of the same restructuring process many new, small firms are often created, the new technologies making small batch production more profitable. To be successful in the market requires that these new, small firms take over some of the functions of existing firms, whether by clustering production in new ways or including new functions and supplying new products. There is a need for a broad shift of government support from existing firms with established positions towards entrepreneurship in its formative stages and towards infrastructural and intangible investment. Growth of small firms and their geographical dispersion also depends importantly on there being in place appropriate telecommunications infrastructures in networking, as well as on availability of venture capital and community services.

Regional Policies and New Employment. There may be an initial tendency for the new technologies to exacerbate regional disparities because the necessary human capital, institutional framework and social attitudes tend to be concentrated in already dynamic areas. However, at the same time the new information technologies weaken the hold of traditional factors on location decisions, and offer the opportunity for more decentralised economic activity whenever the technology-induced reduction of information and communication costs, and lower land prices offer more substantial savings than the increase of transportation costs resulting from decentralisation. Regional, educational, urban and rural development policies should be changed so as to foster the skill, entrepreneurship and social infrastructures which foster local resources to promote indigenous development. There are several examples in which the supply of relevant, technology-intensive skills at local level has led to the creation of new economic activities and local development.

RECOMMENDATION

Social innovations are required in order to translate technology-induced productivity gains into higher employment. The "active society", in which all members are equipped for, and can perceive themselves and be perceived as, making a useful contribution to economic and social life, should become an objective of public policy. The new technologies could contribute to the achievement of this objective. They have the potential to facilitate the wider application of alternative work schedules, to foster job creation in response to new service needs and through the maintenance and redeployment of the existing public infrastructure in such areas as education, information, environment and urbanisation, to revitalise old and traditional industries, and to create new economic opportunities for small firms.

G. INCREASING THE FLOW OF INVESTMENT

Interdependence of Tangible and Intangible Investment. The key to job generation is a greater flow and appropriate spread of investment. Both physical and intangible capital have to be augmented. The potential of physical capital to create jobs will be realised only if it is matched by sufficient and appropriate investment in the skills of the labour force. The flow of investment depends on a variety of conditions, notably entrepreneurship and profitability. Again we stress the interdependence of our proposals. While new technologies have opened up options for small, decentralised entrepreneurship, the exploitation of opportunities has so far been limited by inadequate networking and infrastructures and the limited supply of skills and venture capital. Innovative approaches to financing and governmental and community support for infrastructure development can play a significant role in stimulating entrepreneurship. Member countries differ considerably in the institutions providing for venture capital, and much can be gained by sharing successful experiences. Education is also important; while it may be inherently difficult to teach entrepreneurship, the education system can help to foster the entrepreneurial spirit.

Raising the Level of Investment. Meeting the demands of markets engendered by the new technologies will require major investments in physical capital. The requisite amount of additional investment over the next several years is likely to be several percentage points of national income, especially in Europe. Resources on such a scale will not in most cases be freed through reductions in public expenditure and will have to be generated through some moderation, at least for a period, in the rate of growth of per capita consumption. This may prove more acceptable when the public identifies it with the investment in education and training that raises the productivity and incomes of workers – investment which, by its intrinsic nature, employees carry with them when they change jobs. The general public, including labour, should be encouraged to participate in an investment drive, through profit sharing, investment and pension funds and other creative ways of financing job-creating investments in the private sector. The widening of capital ownership, including co-operative ownership, is important in this policy. In the past, co-operative ventures have often failed through lack of relevant management skills and experience. The far greater pool of skilled and experienced people today and the general rise in levels of education have created a new and more favourable basis for these ventures.

RECOMMENDATION

Special attention should be given to creating an investment climate in which decisions to augment physical capital go hand in hand with decisions to augment intangible capital. The creation of work opportunities on a scale sufficient to make inroads into unemployment requires moderation in the growth rate of per capita consumption in order to provide funds for the additional investment needed in such areas as infrastructure and human resource development. Traditional modes of savings need to be supplemented by new approaches. Various forms of profit sharing and the spreading of capital ownership should be encouraged in order to win not only the support but also the active participation of the general public, including labour.

H. EXPANDING THE MARKETS: INTERNATIONAL ASPECTS OF THE STRATEGY

An Expanding World Market. The sustained growth of the world economy is a necessary condition for the success of national strategies for employment, investment and technical change, and a global recession would represent perhaps the most serious threat to the success of these policies. Major efforts will be needed to ensure a continued growth of international markets. Experience in the 1950s and the 1960s showed how rapidly incipient technological gaps between Europe and the United States were narrowed by concerted international action to reduce barriers to free trade, international investment and the flow of knowledge. Governments have a responsibility to maintain and extend this framework. This implies not only the effort to fight protectionistic tendencies, but also, taking a longer-term view, to extend the possibilities of market growth outside the OECD and to co-ordinate growth policies.

International Policy Co-ordination. The economic interdependence of OECD countries, and of the global economy more generally, will progressively reduce the scope for individual countries to influence and regulate the pace of introduction of new technologies. This does not imply, however, that countries exposed to international competitive pressures will have passively to "endure" the consequences of change. What is required is the design and pursuit of policies which influence and regulate the response to change. This in turn requires a heightened awareness of the direct and indirect implications of technological change and the development of appropriate policy instruments which can best be summarised as the "social management of change".

Disequilibria, International Co-operation and the Role of International Institutions. New initiatives may be necessary to ensure the harmonisation of economic policies and to prevent current international disequilibria degenerating into a downward spiral. Different capabilities in the OECD countries for overcoming institutional and social obstacles may result in increased disequilibria and widening technological gaps. The OECD and other international institutions should foster co-operation to limit the risks of emerging dualism among countries. This applies especially to the international indebtedness problems of many Third World countries. Furthermore, it should be recognised that the less developed countries will be unable to catch up without a major breakthrough in the accumulation of intangible capital, notably skill formation. It is in the self-interest of the industrialised countries to assist them in improving the specific capabilities of adopting new technologies so that they can participate more fully in a process of balanced world economic development.

The Newly Industrialised Countries. It is necessary to take into account the very different circumstances of Third World countries. Large economies such as Brazil and Mexico could join the ranks of the NICs as a competitive force in world markets for sophisticated manufacturing thanks to their relatively advanced infrastructure and their intangible investment in education and research. China and India, although still facing enormous problems of infrastructure, organisation and human resource development, may also eventually follow. In this period of radical, paradigm change, the probable advance of some large economies offers a big opportunity for sustained growth in world markets. A combination of low labour costs and new technologies could give them powerful advantages in contrast to the technologically backward developing countries, whose prospects on world markets are increasingly precarious. The competitive position of the OECD countries can be safeguarded only through a conscious strategy of continuing innovation and change. Access to

OECD markets' investment and technology could be shared in exchange for new markets in the emerging NICs. This strategy should help foster a mutually supportive and more stable world.

The Soviet Union and Eastern Europe. Nor can the Socialist countries be left out of consideration. As they struggle to overcome their internal problems there may be many opportunities for mutually beneficial exchanges in trade and technology, which could contribute greatly to a prosperous and expanding world economy and, through the relaxation of tension, to arms reduction.

RECOMMENDATION

A socio-economic strategy for new technologies would not succeed without an expanding world market. Extended trade flows between the OECD area and the NICs as well as the Socialist countries would benefit all, including indirectly the less-developed countries. However, for the latter group of countries more is needed in terms of technology co-operation and the transfer of know-how from the highly industrialised countries. We believe that these countries should be assisted by the industrialised countries to build up their stock of human capital and social infrastructure to enable them to participate in balanced world economic development.

I. A NEW PATTERN OF RESEARCH, DEVELOPMENT AND DESIGN

A New Pattern of Integration for Research and Development. The expansion of markets depends on new products and processes, and thus on R&D. The new technologies, especially information technology and bio-technology, have close and continuing links with fundamental research, reflected in the expression "basic technology". A number of governmental and intergovernmental programmes are now concerned with the links between basic science and generic technologies. A new pattern of funding is emerging, which seeks to bridge the divide between the academic and the industrial research communities. Information technology itself facilitates the development of links. At the same time, horizontal communication within the enterprise itself between research-development, design, production and marketing becomes more important. "Taylorism" is obsolete not only in production but throughout the enterprise. Vertical command structures are yielding to horizontal information interchange. The trend towards reintegrating R&D with the other functions of the firm while reducing departmentalisation and specialisation corresponds in our view to a trend in society at large.

Over- or Under-Investment in R&D? Fundamental research has long been regarded as a special case, justifying substantial public support where the long-term social benefits exceed the scale of private investment. The general response to the traditional policy question, "Is there market failure or suboptimality in science or technological effort?", is that market failure is indeed one of the intrinsic characteristics, but this does not carry the discussion very far. Indeed, these arguments have on occasion led to the justification of big national and international R&D projects financed and planned directly by state and government agencies, and have thereby become some of the most dramatic illustrations of "government failure". The complexity of the problems involved suggests that general principles and statements about the appropriate roles and relative merits of governmental and private activity in the field of R&D policy will neither describe the experience accurately nor provide much normative guidance.

A Strategy for Technology is More than a Policy for R&D. Since technological and social change form an integrated process, the diffusion and management of innovations can no longer be treated as the Cinderellas of technology policy, but need to be treated as an integral part of technology policy. For this reason our Report does not concentrate on the purely quantitative aspects of R&D expenditures, although these continue to be important. Policies affecting technological change need to encompass more than just R&D and embrace the entire spectrum of scientific and technological activities from invention to diffusion, from basic research to technological mastery. For this reason we stress again the complementarity of our various proposals relating to education, skills, investment, and work organisation.

Enhancing Technological Capabilities. We are not concerned with recommending big increases in expenditure on particular projects or programmes, although we do believe that the problem of fundamental research needs some attention. Rather, we are concerned with the effectiveness of the social systems which generate and diffuse technical innovations, and with the social integration of technological change, within firms as much as within society at large. The creation of technological capabilities involves an endogenous process of change, "mediated" with society at large, and this implies that policies in the area of science and technology will not be, nor should be, limited to questions about the economic "integration" of technological change. Economic, but also social and ethical, factors will increasingly determine which technical innovations will be adopted, or even selected. It is in this context that the discussion of the work environment and industrial relations finds its proper place.

RECOMMENDATION

Technological innovation and social change must be seen as an integrated process and should be managed as such. The diffusion and management of innovation must be an integral part of any technology policy. Policies for technological change need to encompass more than just R&D, to give prominence to the labour market, the education system, enterprises and the various other social aspects which our Report highlights.

23

J. TOWARDS A BROAD-BASED CONSENSUS: THE ROLE OF CONSTRUCTIVE TECHNOLOGY ASSESSMENT

The Need for Constructive Technology Assessment. We have so far considered mainly the issue of worldwide diffusion of information technology. The social nature of the process of technological change is illustrated even more clearly by bio-technology. These technologies have important impacts on the processes of birth, death, crime and disease detection and prevention. They raise important environmental and ethical issues which are likely to bear on the prevailing values of society. The costs and benefits they generate can potentially be large, and their incidence may differ significantly for different groups in society. Hence, there is need for analysis so that the mismatches, the wrong investments and possible social conflicts can be minimised, while at the same time the beneficial effects and opportunities can be fully exploited. It is in this context that we view the issue of technology assessment: as a means of informing the people concerned, generating constructive public debate and encouraging public understanding and involvement. Parliaments do not have the time, the resources or the expertise to explore many of the complex issues involved. Institutional arrangements in OECD countries vary a great deal, but we would see some link with the elected legislature as an essential feature of technology assessment.

Assessment is a Continuing Process. From the perspective adopted in our Report, the long-term implications of technical change, the "externalities" in economists' jargon, will generally speaking not be susceptible to definitive once-for-all categorisation, but rather be more intimately related to particular historical and institutional contexts. Processes of change are continually creating new "externalities".

Technology Assessment and the New Strategy. The current policy debate about some of the long-term, international "externalities" of technological change – its impact on the environment (air, land and water pollution), on privacy and on society's future genetic capital (genetic manipulation, pre-embryo research) – create the need for technology "assessment" and institutional experimentation in science and technology. Governments face a major challenge: how to assume the State's function as social "creative" regulator of technical change in a period of deregulation, itself aimed at stimulating further innovation. It will be tempting, but wrong, to equate the need for "less State" with the notion of "technological laissez-faire". Government science and technology policy is at a crossroads. The policy trajectory which has survived over the last 30 years, with its almost unique focus on R&D, needs to have its boundary lines redrawn. These lines will be broader, less minimalistic, and less "market failure" inspired than they appeared at the outset. They involve a new phase of experimentation with new institutional structures and arrangements, the outcomes of which cannot be fully predicted. This is a time for imaginative social innovations as well as technical innovations and – given the interdependence of the global economy – a time for monitoring, analysing and assessing national experience and results with a view to build up international co-operation.

RECOMMENDATION

Our starting point was that technological change is a social process. From that follows the need for a broad-based consensus about the impact of new technologies on the social fabric, both at the national and the international level. We therefore recommend the further development of various forms of technology assessment which should be a continuing process and in which elected legislatures should equip themselves to play an active and informed though not an exclusive role. The basic aim should be to provide information to those concerned, to promote and participate in a constructive public debate in a wide circle of institutions, thereby strengthening the democratic process through increased public understanding of, and involvement in, the process of change.

ANALYTICAL REPORT

INTRODUCTION

Ever since the Industrial Revolution, there has been a continuing debate over the impact of technology on jobs and, more broadly, on society. Critics of technology have emphasized its dangers and costs; others have viewed technological change as a panacea, offering the unconditional guarantee of jobs and social progress. Consensus has proved difficult, largely because most studies of technological change suffer from two defects. First, they often examine its influence on the production system only, ignoring the impact on society as a whole – yet clearly, the advent of the new technologies in particular has affected the biological and ecological systems as well as the economic system. Second, these studies consider technological change to be exogenously determined, something to which society must then adapt.

The starting point of this Report is the interdependence of technological, economic and social change. Technological change is appropriately viewed as a social process, an integral part of the process of continuing change. Isolating economic from social aspects can only result in an incomplete comprehension of the overall impact and (more importantly) insufficient recognition of technology's role as an endogenous element, one that can be influenced and fashioned by society. These considerations suggest that the understanding and effective management of the process of technological change require an approach involving the expertise and analytical tools of several disciplines.

The Report is structured as follows. The first chapter discusses the main characteristics of the new technologies now diffusing through the OECD economies. The perspective is relatively long term, and takes into account not only the contemporary scene but also the likely developments beyond the turn of the century. Chapters 2, 3 and 4 focus on the decade ahead, examining the more immediate economic, organisational, and educational impacts respectively. Finally, Chapter 5 raises broader societal issues, again in a longer-term perspective.

On the basis of these analyses, the Group has argued for a socio-economic strategy for deriving the maximum benefit from the new technologies while limiting their adverse consequences. The strategy, which is documented in the Conclusions and Recommendations, follows from the view of technological change as a social process. This view emphasizes that it is necessary to take into account the key sets of interrelationships that affect technology decisions and outcomes, and that there is no unique, deterministic way in which technologies are applied – a point that is especially apparent from the very different approaches adopted by Member countries. Indeed, these considerations indicate that a choice among different approaches is possible.

The two key tenets of the strategy are that an advanced capacity for continuing the rapid pace of innovation needs to be maintained and that a high rate of diffusion is to be fostered. The latter is not possible, however, without increasing the flow of investment, especially intangible investment, nor without the aid of social and institutional innovations, which are needed in the following six areas: *i)* mechanisms for generating a greater flow of investment; *ii)* flexibility in the enterprise, management strategy, and entrepreneurial initiative, especially in the context of small firms and regional development; *iii)* flexibility in the industrial relations system; *iv)* improvements in the international flow of technologies; *v)* responsiveness in the education system; and *vi)* a government role in regard to R&D policy and technology assessment.

Chapter 1 draws a distinction between those technologies that may be having a significant economic impact now or presently, such as the information technologies (IT) and other technologies whose economic impact may be limited now or in the short term but which are, nonetheless, beginning to raise important ethical, legal and social issues. Both types of technologies need to be examined. The chapter finds that for a variety of reasons, the new (especially information) technologies represent a significant technological break with the past – what may be characterised as a paradigm – and are capable of giving rise to disequilibria of various kinds. At the same time, the pervasiveness of the information technologies (and dramatic decrease in information processing costs) and their potential for raising not only the productivity of labour but also that of capital, energy and other factors of production point to their important economic significance.

Unfortunately, realisation of this potential is not automatic, a point that is developed in Chapter 2. Even though the leading edge sectors exhibit higher-than-average productivity growth, aggregate productivity measures show a puzzling decline in the growth rate since the early 1970s. While many factors are responsible for this development, the new technologies provide a major clue to the puzzle. There is, in general, no unique way in which the new technologies are or can be implemented. For productivity gains to be harnessed, radical technological change needs to be accompanied by major institutional changes, not only at the level of the enterprise but also more broadly in society. Failing this, the anticipated gains in productivity may not materialise.

The wider diffusion of these technologies is itself dependent upon successful harnessing of the productivity potential. It also requires a higher flow of new investment embodying the new technologies, especially if they are to be accessible to small firms. Finally, there is an international dimension to the whole process of diffusion. Significantly differing rates of technological advancement across countries can contribute to structural imbalances and strain the process of growth in the global economy. Productivity gains are most easily realised when the international economy is growing in a balanced fashion, generating a virtuous circle of technological advancement, economic growth, and gains in employment and welfare.

The point that there is no unique way of introducing new technologies is further developed in Chapter 3, at the enterprise level. Various enterprise functions, such as design, production, inventory control and marketing, need to be more closely integrated than before. This calls for changes in work tasks – typically a substantial upgrading and broadening of skills and job definitions – and in work organisation, which generally involve greater worker participation and responsibility, less hierarchical control, and flexible scheduling. These developments translate into a growing need for a multi-skilled workforce that can take on the challenges presented by changed work organisation. To meet this growing need, action is required at the level of the enterprise and in the education, training and industrial relations systems.

Firms need to pay increased attention to intangible investment, the training of workers, and flexibility in work scheduling arrangements corresponding to both the aspirations of the labour force and the intensive use of new and expensive capital equipment. For this purpose, the meaningful and early involvement of managers and workers, and their respective representatives, is needed at enterprise level. Moreover, firms need to complement their own specific training programmes with the public training system, which calls for enhanced co-operation between the two.

In the context of the growing importance of intangible investment and human resource development, Chapter 4 outlines the key role the education system is required to play. To provide an adequate basis for the flow of new skills and the necessary supply of creative and highly qualified people, and to facilitate mobility of workers across industries, occupations and employers, action is needed in several areas. The minimum threshold of competences needs to be raised for all young people, in combination with training opportunities for transition into working life. For adults, especially those seeking to qualify themselves for entirely different occupations, appropriate institutions are needed to permit general upskilling and the conversion of skills that are becoming obsolete. The need for improved co-operation between the education sector, industry and the trade unions is thus indicated.

R&D policy and the role of technology assessment is taken up in Chapter 5 in the context of the broad societal effects of emerging new technologies. An important role government can play is to create a policy environment that fosters an adequate flow of innovations. An advanced R&D capacity is essential, but there is also the need to move away from the limited view of traditional technology policy towards a more global view of innovation management. Such an approach would be the best way of ensuring that the benefits of the new technologies are realised, and that their costs are kept under control. At times the costs may be concentrated on a few, while benefits are widely distributed. However, the reverse situation is also possible. The costs of making inappropriate choices can be rather large; in some cases, technological change may produce results which conflict with agreed social values. For these reasons, a society needs to have mechanisms available through which it can formulate decisions regarding the shaping of technologies, their acceptability and rate of diffusion. Technology assessments, both public and private, offer one such mechanism.

Long-term development should be viewed as a process of matching needs and lifestyles. Successful matching is the goal towards which the OECD countries must work. It is because this goal *can* be pursued – by each country individually but also jointly in view of their common vital interest in taking up the challenge of the new technologies – that the central point of the Report is stressed: technological policy can no longer be regarded as an isolated phenomenon, but must be taken into account *in all dimensions* of national and international policy-making. Economic, defence, employment, trade, and regional policies are now heavily affected by worldwide developments in technology and any disequilibrating effects that ensue.

Chapter 1

THE NEW STRUCTURAL CHALLENGE

There are intimate and lasting connections between technical innovation, economic development and social and institutional change. This interaction is a central theme of the Report. A good way to begin a study of the employment and social implications of these interrelationships is to consider which technical innovations and technologies are important by virtue of their economic and social consequences. This chapter argues that some of the new technologies have had an impact on the production system – and therefore their measurable macro-economic impact can be significant – while others affect society directly without necessarily having a major impact on the economy. For different reasons, both types of technologies need to be considered. The chapter develops a taxonomy of technical change which is used to rank the economic impacts of various emerging technologies. The focus is on the information technologies (IT), since they are found to be by far the most pervasive.

A. A TAXONOMY OF TECHNICAL CHANGE

In distinguishing between these types of innovations, it is essential to begin by recognising that there are some innovations which have very widespread societal effects and may change the whole quality of life, but whose quantitative economic effects are so small that they have no perceptible influence on the behaviour of economic aggregates. An example is "genetic fingerprinting" – a new advance in bio-technology that could be of great importance in forensic medicine and crime detection. It could have major implications for medical prognosis and life insurance, which will raise questions of medical and social ethics. The innovation has already been applied to immigration control, and has many more potential uses. However, even if genetic fingerprinting comes into widespread use, its *economic* significance will be very slight – thus, it has little or no effect on output or employment.

A second distinction is between innovations that find applications in only one sector and those that affect many or all sectors of the economy. Again, an example will be helpful. The Pilkington "float glass" process introduced in the 1960s was certainly of enormous economic importance for that firm and for the glass industry generally, as it was licensed to nearly every major glass manufacturer in the world over the next few years. However, it has few applications outside the glass industry and its macro-economic significance is therefore relatively small. If this is compared with the electronic computer, which has found applications in every single sector of the economy without exception, the distinction becomes clear. Computers are now used in every industry and service, but they are also used in all the main *functions* within the enterprise: administration, production, design, marketing and research.

The third important distinction clarifying our approach is between a generic technology and a single discrete innovation. Clearly the most important new technologies may give rise to a whole series of innovations or clusters of innovations over a long period. This was the case, for example, with steam-power and electric power in the past, and it is the case with bio-technology and information technology today.

Although specific discrete innovations may have major impacts in one or two sectors of the economy or on society generally, the main concern in the first four chapters of the Report is with the identification of those pervasive, generic technologies that have the greatest macro-economic effects, especially in the sphere of employment. The following taxonomy of technical change will be used to identify these technologies:

1. ***Incremental innovations***. These are occurring all the time throughout the economic system, although at varying rates in different sectors of the economy. They are often included under some general heading such as "learning by doing" or "learning by using". Although their cumulative effects are very important for long-term productivity growth and for quality improvements, they affect only the existing array of products, services and processes. They are reflected in the official economic statistics by changes in the coefficients of the existing input-output matrix and in technology statistics mainly through patents, but they do not necessarily involve organised R&D. Hollander's (1965) study of the productivity improvements in DuPont's rayon plants showed that most of the incremental improvements indeed came from outside R&D: from plant production engineers, technicians and operatives. Such innovations may even go unrecorded. The important point is that although they are of great economic importance, they do not raise any major problems of structural adjustment because they do not require entirely new skills or types of capital equipment – instead, they call for improvement in the use of already existing resources;
2. ***Radical innovations***. These are discontinuous events and cannot emerge simply from the improvement of existing products and processes. For example, nylon could not have emerged from improving a rayon plant. Nuclear power did not derive from oil- or coal-fired power-stations, nor genetic fingerprinting from existing techniques of fingerprinting. Logically, a radical innovation should lead to the introduction of a new row or column in an input-output table, but in practice such changes are made only for the most important radical innovations and even then only after considerable time-lags. A radical innovation does raise problems of structural change, since it requires new types of capital equipment and/or new skills to produce or supply the new product or service – i.e. it implies a discontinuity. However, such problems are likely to be limited to specific components of the economy, unless many radical innovations are clustered together [see 3 below]. The float glass process is an example of a radical innovation with relatively localised effects;
3. ***Generic technologies or "new technology systems"***. Keirstead (1948) introduced the concept of "constellations" of innovations that are technically and economically interrelated. Obvious examples are the innovation "clusters" of synthetic materials and petrochemicals in the 1930s, 1940s, and 1950s. Contemporary examples are the ranges of composite materials and seed and plant varieties based on genetic engineering. Other authors have termed these clusters of innovations "natural technological trajectories" [Nelson and Winter (1977)], "technological paradigms" [Dosi (1982)], "new technology systems" [Freeman, Clark and Soete (1982)] and "generic technologies" [OECD (1980)]. Here the important point is that when a number of radical (and incremental) innovations are clustered together, they may generate more severe problems of structural adjustment, since they can give rise to the growth of entirely new branches of the economy, as well as to the displacement of

older ones. For example, the growth of the synthetic rubber industry had important consequences for natural rubber, and the growth of synthetic materials more generally had widespread consequences on the demand for other natural substitute materials – such as jute or cotton – and on the supply of industries – such as packaging, construction, textile, electrical and automotive – new inputs, equipment, technical standards, skills and products were required;

4. ***Pervasive generic technologies.*** Some generic technologies or "new technology systems" have such a wide range of applications that they affect the conditions of production and distribution in all or almost all sectors of the economy. Steam-power is an example of pervasive technology, since it made possible the mechanisation of most manufacturing processes and, through its application in railway systems and ships, completely changed distribution systems, transport costs and economies of scale for many services as well as for manufacturing. Electric power is another example. Today's most pervasive technology is information technology, defined as a combination of radical innovations based primarily on computers, micro-electronics and telecommunications. Some economists [for example, Perez (1983), (1985)] have used the expression "techno-economic paradigm" to describe those technologies that are so pervasive that they affect the entire economic system. Nelson and Winter (1977) have used the term "technological regime" to describe technologies that are dominant in a particular period. Whatever terminology is used, it is important to distinguish those generic technologies that have the most pervasive effects, since they have the greatest implications for investment, employment and structural change.

B. THE MAJOR NEW TECHNOLOGIES

Most observers agree that the following are the most important new technologies: *i)* information technology; *ii)* bio-technology; *iii)* materials technology; *iv)* space technology; and *v)* nuclear technology. Their importance is recognised in OECD Member countries by the establishment of special programmes designed to advance R&D and to facilitate new applications. In attempting to assess the relative importance of these various technologies and their probable future impact over the next ten years or so, this chapter is concerned solely with their *economic* impact. Naturally, all of them also have profound effects on the quality of life, on social change and on life-styles.

For a technology to have pervasive economic effects and substantial employment implications, it must: *a)* generate a wide range of new products and/or services; *b)* have applications in many sectors of the economy; *c)* reduce the costs and improve the performance of existing processes, products and systems; *d)* gain widespread social acceptance with minimal opposition, leading to a favourable regulatory framework; and *e)* generate strong industrial interest based on perceived profitability and competition advantage. Table 1.1 summarises how the five above-mentioned technologies rate according to these criteria. This is, of course, an over-simplified form of presentation. Although opinions will differ on the relative weighting, the main point that emerges – IT's predominance – is clear, and will be taken up in the next section. At this point, however, the other technologies' salient characteristics are considered.

It is clear that bio-technology already has an important range of commercial applications and a far greater potential range. However, analysis shows that the present applications are confined to only a few sectors of the economy – agriculture, forestry, food, drugs, chemicals,

Table 1.1.

Ranking of economic significance of several generic technologies[a]

Characteristics favouring or retarding diffusion	Bio-tech.	Materials	Space	Nuclear	Information
Range of new products and services	4	4	2	2	9
Improvements in costs or technical attributes of existing processes, services and products	3	4	2	1	9
Social acceptance	5	9	6	3	9
Strength of private industrial interest	3	6	3	2	10
Sectors of application	4	4	2	2	10
Probable employment impact in 1990s	2	2	1	1	10

a) A value of 10 represents the highest ranking and a value of 1 the lowest.
Source: High-Level Experts Group on the Social Aspects of New Technologies.

health care, water treatment and minerals. The number of people employed is still very small indeed (referring only to the "new" bio-technologies, not to the traditional brewery and food industries). Moreover, the cost comparisons suggest that in many potential areas of application such as bulk chemicals, energy and animal food-stuffs, the new techniques are not yet competitive. They are only likely to become so in the event of major new R&D results or a substantial change in the prices of non-renewable resources. In other areas, such as food processing, applications are held up by uncertainties both about public acceptance and in the regulatory environment. Thus, while bio-technology may bring about major qualitative changes in society, it is not likely to be a dominant technology or have much effect on employment before the next century. In the long term, effects may be very great because of the influence on agriculture and the possibility of a breakthrough in bio-chips, or "bio-mimicry" in computers, which could lead to a convergence with information technology.

Certainly new products are introduced in the case of materials technology. Primarily, however, materials enlarge the portfolio of available choice to the industrial designers and enable the most desirable qualities and attributes to be chosen at an early stage. This "customising" of materials is closely associated with the introduction of computer-aided design (CAD) and other information technologies.

Perhaps even more than bio-technology, space technology is of interest in the very long term. Apart from its enormous significance in defence areas, contemporary applications are almost entirely in the communications area – again, there is a link to the future development of information technology and especially of the worldwide telecommunications infrastructures. Despite its great strategic significance, the employment impact of space technology is likely to be very small.

Social acceptance (or, more precisely, non-acceptance) has greatly retarded diffusion of nuclear technology. This has even more to do with the interaction of safety considerations and economic factors than with the environmentalist opposition in many countries. The delays and specification changes arising from the regulatory process, however justifiable they may have been, have greatly increased the capital costs and have reduced diffusion to a snail's pace in such countries as the United States and Germany. At the same time, energy-saving technologies such as IT have led to forecasts of reduced energy demand. Furthermore, applications in the sphere of transport systems have not proved cost-effective. Of course, the military uses of nuclear technology ensure its continuing worldwide importance, in spite of reduced relative economic and employment significance.

C. INFORMATION TECHNOLOGY (IT): THE MAIN CHARACTERISTICS

The major technologies reviewed thus far are all heavily dependent on information technology in their research, management and control systems. The widespread recognition and singling out of IT as being at the centre of the present wave of technological change in most OECD countries is therefore not surprising. As Flamm (1987) observes, "The price of information processing and computing power has fallen at a roughly continuous rate of some 25 per cent per year in nominal terms, almost 30 per cent per year in real terms, over the last three decades. By way of contrast, the commodity price most affected by technical progress during the first industrial revolution – cotton cloth – fell at a rate of roughly 3.4 per cent per year, a full order of magnitude more slowly, during the late eighteenth and early nineteenth centuries". One of the main attributes of a pervasive technology is a reduction in the cost of a key factor [Perez (1983)], and indeed it is this dramatic decline in information costs that is at the core of the pervasive and all-encompassing impact of IT.

Evidence with regard to the rapid rate of technological change in micro-electronics and computers and the potential impact on user sectors can be found in some of the computer performance "engineering" data. These data highlight the dramatic improvements in information processing performance, e.g. in terms of computer speed, cost and capacity. Table 1.2 and Chart 1.1 provide a summary of this evidence for the period up to 1978. Estimates of real computer prices for the more recent period point to similar continuous cost improvements [Cole *et al.* (1986)].

The term "information technology" reflects more accurately than "automation" the convergence of computer technology and related developments in telecommunications. This combination is extremely powerful in terms of both economic and technical advantages; its

Table 1.2.

Computers with highest performance indices
at the time of their introduction 1951-78

Computer	Year	Speed (Kops/sec)	Cost (Kops/$)	Capacity (Kbytes)	Index[a]
Univac U1	1951	0.27	7	8	0.011
IBM 650	1954	0.29	45	20	0.027
IBM 704	1955	3.79	50	192	0.246
IBM 709	1958	10.23	91	192	0.265
IBM 7090	1959	45.47	443	197	0.378
CDC 1604	1960	20.40	374	256	0.381
IBM 7094	1962	95.90	842	197	0.526
CDC 3600	1963	74.90	849	2 048	2.731
CDC 6600	1964	4 090.00	33 988	1 280	13.694
BGH 6700	1969	8 886.00	81 540	6 144	34.170
CDC CYB/76	1972	10 220.00	38 632	5 770	35.479
IBM 3033	1978	19 019.00	65 932	16 384	72.675

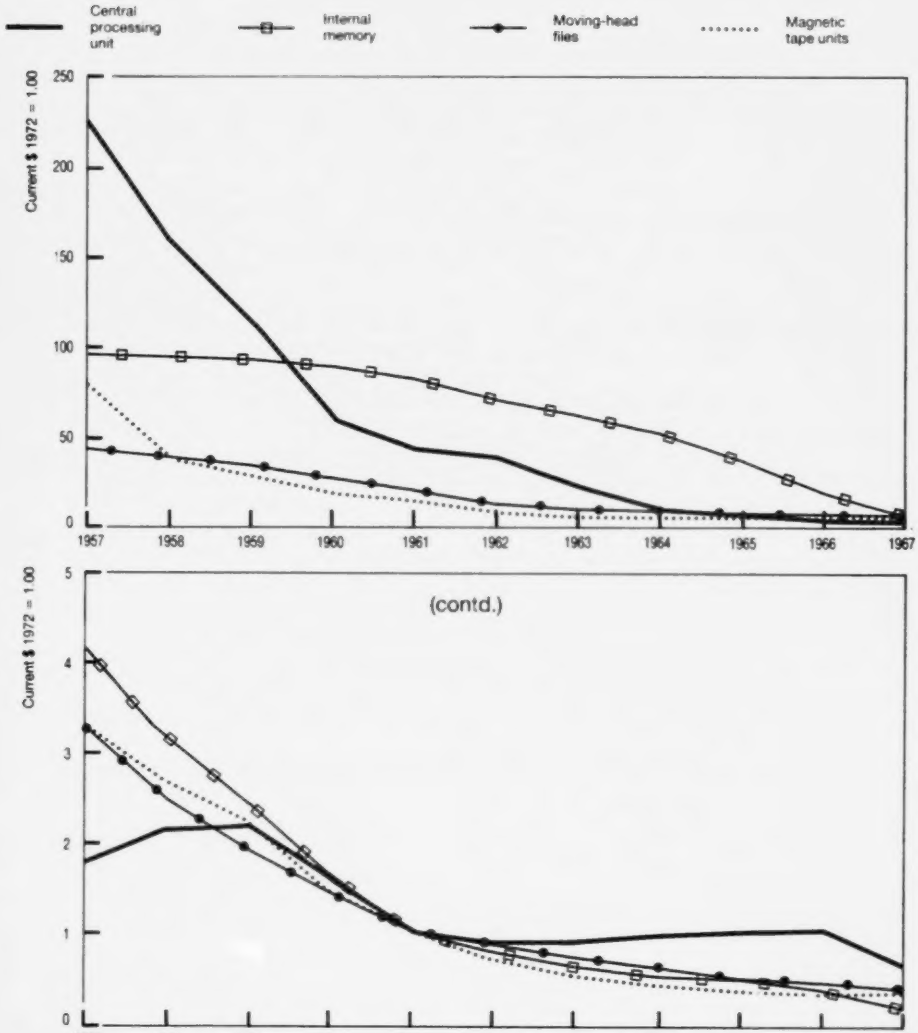
a) The index is computed as a weighted average of the changes in the parameters relative to speed, cost and capacity of computers.

Source: National Science Foundation (1980).

Chart 1.1. **TRENDS IN PRICES (ADJUSTED FOR PERFORMANCE) PER UNIT BANDWIDTH**

(System components)

1957-1978[a]



a. A two-year lag on speed measures is used to reflect vintage effects in the population for other than central processing units.

Source: Flamm (1987).

actual and potential applications go far beyond those customarily discussed in the 1950s debates on automation. A second reason for preferring the term "information technology" rather than "automation" is that the latter connotes an exclusive concern with process innovation. Although labour-saving technical change is most certainly one of the major economic advantages of the new technology, this aspect has been greatly over-emphasized at the expense of other equally important characteristics. Information technology has already demonstrated very great advantages in material-saving, energy-saving and capital-saving applications – for example, in the reduction of the number of mechanical and electronic components in engineering products ranging from cash registers to machine tools, or in the reduction of inventory. More fundamentally, the emphasis on labour-saving process automation technology tends to overshadow the development of new products and services associated with the new technology.

The main characteristics of present-day information technologies can be summarised as follows:

a) A continuing high rate of technical change in electronics-related industries themselves, as well as in a wide range of applications. Underlying this process is the continuing dramatic improvement in large-scale integration of electronic circuits, and the continuing reduction in costs which this permits. The "revolutionary developments" in integrated circuits have their parallel in communication technology, where fibre optics have made possible similar dramatic improvements in costs and performance. The convergence of these technological advances means that the power to communicate, process and store information is still increasing very rapidly at a price that continues to fall. This leads to the development of new types of data banks and information services, and has profound consequences for the integration and control of production activities; the capability to integrate design, manufacture, procurement, sales, administration and technical service in any enterprise encourages a tendency towards computer-integrated manufacturing and all-electronic office systems, but it is very unlikely that this will result in an unmanned factory or a "paperless" office;

b) The capability to improve the quality of products, processes and services. On-line monitoring and control of output quality has already led to striking improvements in products as diverse as colour television sets and motor cars. It permits capital-saving, labour-saving, materials-saving and energy-saving improvements in production processes since it reduces the number of rejects and wasted components for both intermediate and final output;

c) The capability to link up networks of component and material suppliers with assembly-type firms (e.g. the motor car industry) or with service firms (e.g. the hotel and catering industries). Equally important, IT can link producers, wholesalers and retailers. In both cases it is the convergence of communications and computer technology that permits savings in inventories at all levels in the system, especially in work-in-progress, and a more rapid and sensitive response to daily changes in consumer demand (IKEA in the furniture industry and Benetton in the clothing industry are examples). Furthermore, the new flexibility and speed of communications systems and their links with data banks permit a wider variety of new "Value-Added Networks" (VANS) and new types of information services;

d) Much greater flexibility in rapid model changes and design. Some analysts have referred to this phenomenon as "economies of scope", replacing to some extent "economies of scale". Whereas previous assembly line and flow production systems were relatively inflexible and based on the continuous replication of vast numbers of standardized, homogeneous products, the new flexibility permits more rapid changes of tooling and dies, so that small production runs become economic and the prospects for small and medium-sized firms are greatly improved, reducing the barriers to entry and permitting major changes in industrial structure;

e) A reduction in electromechanical components and in phases of component transformation as a result of the redesign of products and processes. This leads to substantial savings of materials and energy, as well as to a process of structural change involving the loss of jobs in some metals and metal goods sectors and an increase in jobs in some sectors of the electronic components industry, electronic products and producer services;

f) As a result of the changes outlined above, and in particular as a result of the continuing high rate of technical change in the micro-electronics and computer industries themselves, a strong tendency towards a more rapid rate of product and process change and more intense technological competition. In turn, this strengthens the demand for new skills and services in design, development, software engineering and micro-electronics generally, affecting both in-house skill and employment profiles and the growth of new services, information flows and equipment supplies. The more rapid rate of product and process change is itself facilitated and stimulated by the diffusion of computer-aided design systems;

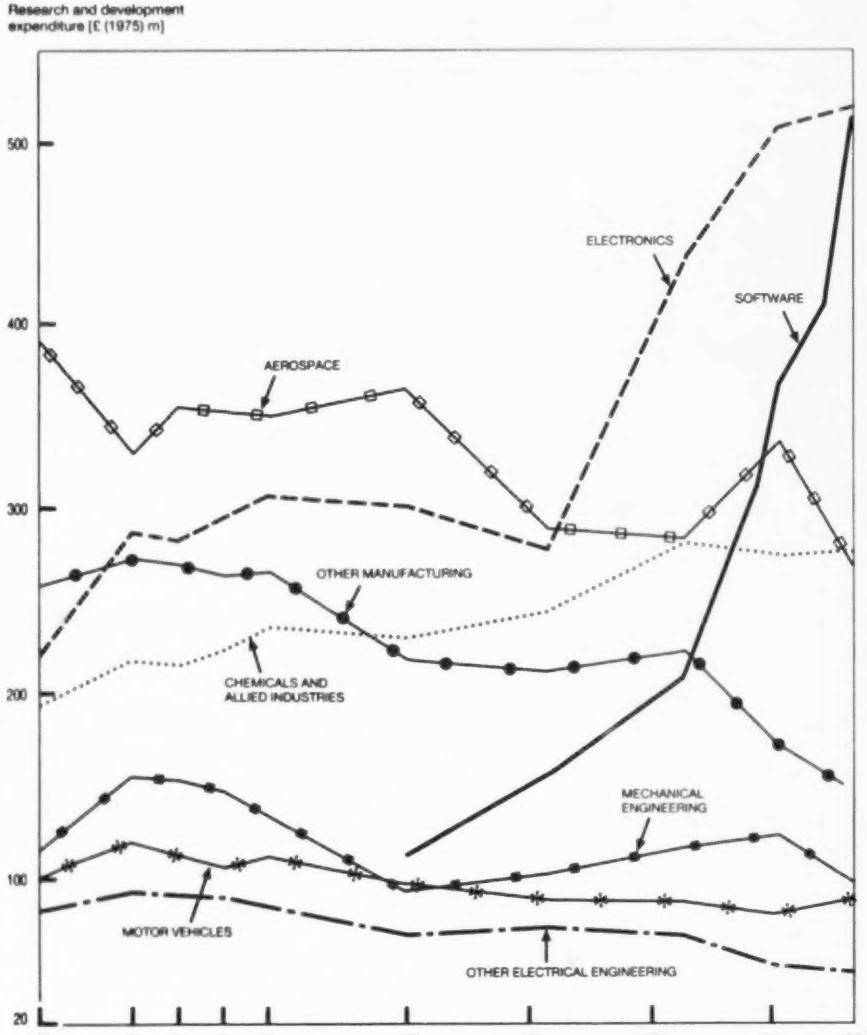
g) All of this means that IT is affecting not only the structure of the economy in terms of new industries and services, but also the internal structure and management of all enterprises and the relationships between them. There is a tendency in the more successful firms towards the horizontal integration of R&D, design, production and marketing, as opposed to the traditional Tayloristic pattern of vertical, hierarchical control. People and information move more freely between the various departmental functions, and new channels of communication are established within and outside the firm.

D. THE PERVASIVENESS OF IT

While most people would accept this description of the actual and potential impact of IT, there is still some reluctance to accept its full implications. For example, it is often said that the output and employment of the IT sector amount to less than 10 per cent of manufacturing production, even in the leading countries. Also, it is argued that if IT is so important and so advantageous, one should see its effects in an acceleration of productivity increases. It is widely noted that we see computers everywhere but we do not see the productivity. (This important point will be taken up in Chapter 2.) This section points to further evidence of the pervasiveness of IT: the concentration of R&D expenditures, the importance of software activities and the range of applications in products and processes.

Indirect empirical evidence with regard to the technological performance of information technology sectors can be obtained from some of the more traditional economic sectoral indicator data. The standard way of assessing the importance of a particular technology sector is to look at how much is spent on research and development. This approach focuses on an input approximation of technological efforts, and ignores intersectoral differences in the efficiency of R&D as well as inter-industry technological flows. It does, however, bring out the overriding importance of some technologies.

Chart 1.2. **TRENDS IN INTRA-MURAL EXPENDITURE ON RESEARCH AND DEVELOPMENT IN THE UNITED KINGDOM 1964-1983**
(1975 prices)



Source: Soete (1987).

R&D-intensive sectors for which data are available in most OECD countries since the mid-1960s appear to have been characterised by rapid output and productivity growth. The figures show a heavy concentration of R&D expenditure in a small number of sectors, including drugs, aerospace, telecommunications, computers and electronics – as shown by Chart 1.2, which plots trends in R&D sectoral expenditures in the United Kingdom in the 1964-83 period. In some of these sectors the crucial importance of this "intangible" investment is illustrated by the fact that the amount spent on R&D is well above that spent on "physical" investment (e.g. in the computer sector).

R&D expenditure in the manufacture of electronics, telecommunications and computers now represents between 20 per cent and 30 per cent of total R&D in most leading industrial countries. It could be argued, however, that this figure still underestimates the concentration of technological effort in electronics. The present method of identifying R&D is indeed heavily biased towards industrial sectors. This implies that much of the technological effort associated with computerisation in industry and services, which takes the form of new software design and applications, is not included in reported R&D expenditure statistics. Yet it is precisely software activity that captures the diffusion and innovative application of the new technology throughout the economy.

Therefore, the trend in software expenditure (at 1975 prices) over the period 1972-83 has been added to the trends in sectoral R&D expenditure in Chart 1.2. By 1983, software expenditures were at about the same level as total R&D expenditures in electronics, having grown even faster over the past five years. It follows that taken together, these sectors accounted for just over 50 per cent of what has been defined as *RD&S*: Research, Development and Software [Soete (1987)]. It should be stressed that in 1975 this figure was only 28.7 per cent (Table 1.3). The contribution of software expenditure in this IT total is

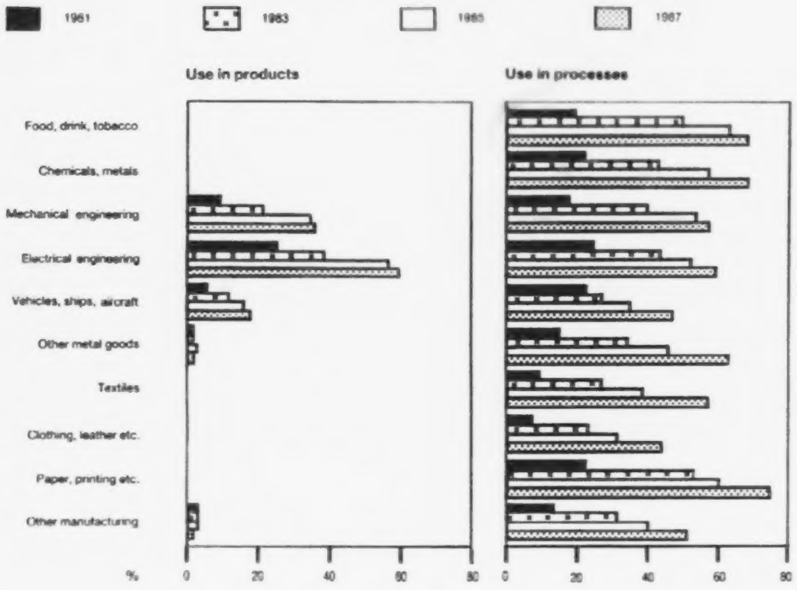
Table 1.3.

Changes in research development and software expenditure in the United Kingdom 1975 to 1983 (in 1975 prices and percentage of total)

	1975		1978		1981		1983	
	£ Million	%	£ Million	%	£ Million	%	£ Million	%
Manufacturing R&D	1 293	86.8	1 512	85.1	1 555	76.6	1 465	70.2
Chemicals	254	17.0	284	16.0	277	13.6	279	13.4
Mechanical Engineeing	103	6.9	118	6.6	111	5.5	99	4.7
Electronics	279	18.7	442	24.9	511	25.2	529	25.3
Other Electrical	73	4.9	69	3.9	53	2.6	45	2.2
Motor Vehicles	88	5.9	88	5.0	80	3.9	91	4.4
Aerospace	291	19.5	285	16.0	337	16.6	272	13.0
Other Manufacturing	213	14.3	226	12.7	185	9.1	151	7.2
Non-manufacturing R&D	48	3.2	54	3.1	106	5.2	99	4.7
Software	149	10.0	210	11.8	369	18.2	524	25.1
Total RD&S	1 490	100.0	1 776	100.0	2 030	100.0	2 088	100.0
Micro-electronics – total Electronics & Software	428	28.7	652	36.7	880	43.3	1 053	50.4

Source: Soete (1987).

Chart 1.3. **USE OF MICROELECTRONICS BY INDUSTRY**
Percentage of all UK factories



Source: Northcott and Walling (1988).

particularly worth noticing and, at a more general level, points to the increasing importance of services in bringing about technical change.

Finally, Chart 1.3 shows the rapid increase in applications in manufacturing in the 1980s. Product innovations took place mainly in the machinery industries, but almost every sector of manufacturing was making extensive use of micro-electronics in processes. Also, the data presented refer to the United Kingdom only, but there is no reason to suppose that these trends in the United Kingdom differ from those in other major industrial countries.

E. CONCLUSIONS

This chapter has outlined a taxonomy of technical change pointing to the overriding importance of some generic technologies that give rise to many new products and processes and to major problems of structural change and adaptation. Among these technologies, information technology has been identified as being by far the most pervasive and influential in terms of its impact across all sectors of the economy, including the service industries. The next chapter will examine the employment implications of the diffusion of this technology and the "productivity paradox" – the fact that while IT was diffusing, productivity growth slowed down significantly in most OECD countries.

BIBLIOGRAPHY

COLE, R. *et. al.* (1986), "Quality-Adjusted Price Indexes for Computer Processors and Selected Peripheral Equipment", *Survey of Current Business*, Vol. 66, January.

DOSI, G. (1982), "Technological Paradigms and Technical Trajectories", *Research Policy*, Vol. 11, No. 3, June.

FLAMM, K. (1987), *Targeting the Computer*, Washington, D.C.: The Brookings Institute.

FREEMAN, C., CLARK, J. and SOETE, L.L.G. (1982), *Unemployment and Technical Innovation: A Study of Long Waves in Economic Development*, London: Frances Pinter.

HOLLANDER, S.G. (1965), *The Sources of Increased Efficiency: A Study of DuPont Rayon Plants*, MIT Press.

KEIRSTEAD, B.S. (1948), *The Theory of Economic Change*, Toronto: Macmillan.

NATIONAL SCIENCE FOUNDATION (1980), *Research into Technology Output Measures: Report to the Science Indicators Unit*, Glastonbury, p. 123.

NELSON, R.R. and WINTER, S.G. (1977), "In Search of a Useful Theory of Innovation", *Research Policy*, Vol. 6, No. 1, pp. 36-76.

NORTHCOTT, J. and WALLING, A. (1988), *Micro-Electronics: Promise and Performance*, London: Policy Studies Institute.

OECD (1980), *Technical Change and Economic Policy: Science and Technology in the New Economic and Social Context*, Paris.

PEREZ, C. (1983), "Structural Change and the Assimilation of New Technologies in the Economic and Social System", *Futures*, Vol. 15, No. 4, October, pp. 357-375.

PEREZ, C. (1985), "Micro-Electronics, Long Waves and World Structural Change: New Perspectives of Developing Countries", *World Development*, Vol. 13, No. 3, pp. 441-463.

SOETE, L. (1987), "The Newly Emerging Information Technology Sector", Chapter 10 in FREEMAN and SOETE (eds.)*Technical Change and Full Employment*, Oxford: Basil Blackwell.

Chapter 2

EMPLOYMENT AND PRODUCTIVITY

A. INTRODUCTION

The nature of the new technologies was examined in the preceding chapter. This chapter examines their job-generating potential and their productivity effects. A great deal has been written on the topic since the employment-technology relationship was first studied systematically, about two hundred years ago. This is not the place for a discussion of the various schools of thought that have emerged, nor for an exhaustive summary of the more recent literature in this area. Rather, the chapter takes three major conclusions emerging from this literature as the point of departure.

First, over the long term, technological progress is a (if not indeed the) main driving force behind rising levels of productivity, employment, standards of living and social welfare. Second, a satisfactory analysis of employment impacts must consider the macro system as a whole: loss of jobs from one firm, industry or region may be compensated or more than compensated by new jobs elsewhere in the system. Finally, the process of compensation is neither automatic nor instantaneous and, unless improved, can be painful for society.

There is actually a wider area of agreement than is sometimes assumed between "neo-Schumpeterians", who put the main emphasis on structural change, and those who stress compensation mechanisms. Most economists accept that there are substantial time-lags and institutional rigidities reducing the speed of adjustment to the new technologies, and (at least since Ricardo) that the adjustment itself is a complex process which does not necessarily tend towards full employment. The difference between the two schools of thought lies primarily in the emphasis on factor price mechanisms on the one hand and the pattern of technical, structural and institutional change on the other.

In the neoclassical tradition, the direct impact of technological change is to save input, depending upon the factor augmentation bias. The compensation mechanism operates through indirect effects; reductions in costs are likely to lower prices and induce additional demand. Output expands in response, and with it the demand for factors. Through this process, the indirect effects compensate for the initial reduction in factor demand. The relative strength of the direct and indirect effects depends on a variety of parameters. Hence, on a theoretical basis alone it is impossible to determine which of the two effects will dominate. The outcome is more reliable, however, in the case of product innovation: both the direct and indirect effects are likely to be positive [Katsoulacos (1986)].

Other theorists such as Nelson and Winter (1982) and Freeman, Clark and Soete (1982) draw their inspiration from Schumpeter. They argue that the essence of technological change is not captured by the factor augmentation approach of the neoclassical model, which is constructed on the basis of equilibrium properties. For these authors, technological change is essentially a dynamic disequilibrium process that involves the creation of new products, new "wants" and new industries [see also Pasinetti (1981)]. While this is likely to generate new demand for factors, the employment outcome is by no means certain. This is because the production function is not as smooth as the traditional neoclassical framework implies, and if fixed or quasi-fixed coefficients are allowed into the production function, labour-saving technological change embodied in new investment could lead to structural unemployment. For traditional Keynesians also, there is no necessary tendency towards a full-employment equilibrium, since Keynes denied to both the wage rate and the interest rate the equilibrating power assumed in mainstream neoclassical theory.

The current issues reflect the divided reaction to the new technologies. One the one hand there is the fear that they will raise levels of unemployment – i.e. that in changing the composition of jobs they condemn a segment of the labour force that is deficient in new skills to either total exclusion from the market or low-wage and unstable work. The other reaction emphasizes hope; it sees rapid diffusion of new technologies as the principal way out of a pace of job generation that has been unsatisfactory since the early 70s.

Cutting across these polar views is the central concern of this chapter: the speed and difficulties of adjustment. New technologies require fundamental changes in societal attitudes and institutions, without which the fear of rising unemployment levels is justified and the hope of a major stimulus to jobs mere wishful thinking. The focus will be on the shifts in production functions induced by their diffusion rather than marginal adjustments in input-output combinations, and on the drastic fall in the costs of the storage, processing and transmission of information rather than simply on changes in the relative prices of traditional factor inputs.

Chapter 1 argued that information technology is pervasive and has several new features, and thus has changed the "rules of the game" throughout the system. It is the latest hurricane in Schumpeter's successive "creative gales of destruction". Whereas incremental innovations do not give rise to major problems of structural adjustment, the introduction of a radically new technology system does. This is so because it requires a redesign and new configuration of the capital stock, a new skill profile in the labour force, new management structures and work organisation, a new pattern of industrial relations, and a new framework of institutional regulation at both national and international levels – e.g. in relation to the global telecommunications network or traded information services.

The profundity of this transformation is now generally recognised. There is much talk about the "factory of the future" and the "office of the future". The personal computer, the word processor, data banks, electronic mail and many other new information services are bringing about a dramatic change in the pattern of service activities, many of which are becoming capital-intensive for the first time, and in some cases R&D-intensive. It is precisely this break with past methods of organising design, production, distribution and marketing that leads to problems of structural adjustment and at times to a slow-down in productivity growth. Furthermore, the employment-generating potential of the diffusion of the new technologies can only be fully realised as the organisational and institutional problems associated with any such wave of technical change are satisfactorily resolved.

This chapter focuses on the importance of the productivity potential, the role technological change plays in generating this potential, and how the potential gets translated into employment levels. The nature and causes of the "productivity paradox" are dealt with first, and then the issues of organisational, institutional and social change are discussed. The main conclusion is that the new technologies can make a major contribution to employment generation if – and this is a big if – the macro policy stance is appropriate and consistent micro-structural policies are undertaken by government, various social groups and society at large to realise the employment potential inherent in these technologies. It is concluded that *not* adopting new technologies would be detrimental to job growth, especially when a region or nation lags behind while others forge ahead. As a result, the screening of new technologies and their speedy diffusion become key areas of policy concern.

B. TECHNOLOGICAL CHANGE AND PRODUCTIVITY GROWTH

Productivity growth has played the major role in raising and sustaining employment levels and a significant part of productivity growth stems from technological progress. Hence, technological progress seems to be a key element determining long-term job growth and social progress.

In simplified terms, the growth in output levels can be traced to two sources: more resource inputs and higher input productivity. Economists have developed a simple "growth accounting" framework to illustrate a cardinal feature of the economic growth process. Historically, the rising levels of output in the industrialised world have gone hand in hand with rising employment levels *and* rising productivity – i.e. contrary to a popular belief unemployment levels tend to be higher in periods of low productivity growth. The 1960s were a period of very low unemployment and, as shown by Table 2.1, high productivity increase, whereas the reverse was true of the inter-war period. Since the first oil price shock, the productivity growth has slowed down markedly and levels of unemployment have been higher. A recent OECD study finds that total factor productivity (TFP) growth and employment growth are not negatively correlated in the medium term [Englander and Mittelstädt (1988)]. At the same time, TFP growth and real wage growth are strongly correlated over the medium term. TFP growth tends to improve living standards without reducing employment.

In this accounting framework, TFP growth is often called the "residual", in the sense that it is the part of output growth not explained by the growth in inputs. Some authors refer to it as "a measure of ignorance" of factors which contribute to increases in output. Many attempts have been made to reduce this residual factor, typically by taking into account input quality (skilled labour, new machines), changes in economic structure, foreign trade, economies of scale, structural shocks such as rises in the cost of energy and, for countries other than the technology leader (typically the United States), a catch-up factor. The main problem with this type of analysis, as Nelson (1981) has pointed out, is that it cannot take into account the complementarities and interactions between the various factors – and, as will be seen, these are very important. Aside from measurement issues, which are truly daunting in this field, there are other conceptual problems with the growth-accounting framework. It is essentially an equilibrium approach and, assuming an industry- or economy-wide production function, implies that technological knowledge is public.

Several attempts have been made to extend this neoclassical framework. For example, technical progress has been made endogenous and explained as a function of R&D and, in order to capture embodied technical change, the stock of machines has been measured in terms of vintages. These and other extensions typically reinforce the linkage between technical change and productivity growth. It could be argued that despite such extensions, the neoclassical framework does not capture the full richness of technological change, especially when the potential of trajectories is largely exhausted and there is a change of technological regime (as in the 1970s, as opposed to the established trajectories of the 1950s and 1960s). The above notwithstanding, there is unanimity that the role of technological change as a major determinant of productivity growth is central.

Table 2.1.

Productivity and output growth[a]

Business sector; average percentage changes at annual rates

	1960-1973[c]	1973-1979	1979-1986
		Output	
Austria	4.5	3.5	1.7
Australia	5.6	2.2	2.9
Belgium	5.4	2.0	1.6
Canada	5.7	4.9	2.5
Denmark	3.4	0.9	1.9
Finland	4.7	2.2	3.0
France	6.4	3.5	1.5
Germany	4.6	2.4	1.6
Greece	8.4	3.5	1.2
Ireland	4.6	6.1	-1.2
Italy	5.6	2.9	1.9
Japan	9.7	3.8	3.8
Netherlands	5.6	2.7	1.0
New Zealand	3.9	0.1	2.6
Norway	3.7	5.4	3.1
Spain	6.4	2.7	0.6
Sweden	2.4	1.8	0.8
Switzerland	4.0	-0.6	2.0
Turkey	5.2	4.8	3.5[d]
United Kingdom	3.2	1.1	1.4
United States	3.8	2.8	2.2
OECD average[b]	5.2	2.9	2.3
		Total factor productivity	
Austria	2.8	1.8	0.7
Australia	2.1	0.6	0.5
Belgium	3.7	1.4	1.3
Canada	2.2	1.1	-0.3
Denmark	1.7	0.1	0.8
Finland	3.4	1.5	1.6
France	4.3	2.1	1.3
Germany	2.8	1.8	0.8
Greece	6.6	1.7	-0.5
Ireland	4.0	4.2	-0.9
Italy	4.7	1.6	0.7
Japan	6.1	1.8	1.7
Netherlands	3.1	1.1	0.4
New Zealand	0.6	-2.5	0.6
Norway	2.0	2.9	1.5
Spain	3.4	1.5	0.7
Sweden	1.4	0.8	0.1
Switzerland	1.7	-0.8	0.7
Turkey	0.7	0.3	1.9[d]
United Kingdom	2.0	0.2	1.1
United States	1.5	-0.1	0.0
OECD average[b]	2.8	1.6	0.6

Table 2.1. *(continued)*

	1960-1973[c]	1973-1979	1979-1986
	Labour productivity		
Austria	5.3	3.9	2.0
Australia	3.2	1.8	1.1
Belgium	4.8	2.8	2.3
Canada	2.9	2.0	1.1
Denmark	3.5	1.8	1.7
Finland	5.0	3.1	2.3
France	5.9	3.5	2.5
Germany	4.9	3.4	2.0
Greece	9.1	3.1	0.2
Ireland	4.7	4.8	0.2
Italy	6.5	2.4	1.2
Japan	8.6	3.2	2.8
Netherlands	5.0	2.8	1.6
New Zealand	1.8	-1.0	1.6
Norway	3.0	4.3	2.1
Spain	5.7	4.2	2.4
Sweden	3.1	2.2	1.2
Switzerland	3.4	0.7	1.5
Turkey	0.0	0.4	2.4[d]
United Kingdom	3.3	1.3	1.9
United States	2.2	0.3	0.6
OECD average[b]	4.1	1.6	1.4

a) Output is value added in the business sector (GDP at factor cost excluding value added in general government) at constant prices. Total factor productivity growth is equal to either *i)* output growth minus factor input growth (a weighted index of capital and labour inputs), or *ii)* a weighted average of the growth of labour and capital productivity. In both cases, 1985 capital and labour shares are used as weights.

b) Weighted average of above countries based on the 1985 business sector output at 1985 prices and exchange rates.

c) The starting years are as follows: Austria 1961, Australia 1961, Belgium 1961, Canada 1962, Denmark 1960, Finland 1962, France 1965, Germany 1961, Greece 1962, Ireland 1961, Italy 1961, Japan 1967, Netherlands 1962, New Zealand 1963, Norway 1964, Spain 1966, Sweden 1966, Switzerland 1963, Turkey 1972, United Kingdom 1960, United States 1960.

d) 1979-85.

Source: Englander and Mittelstadt (1988).

If this is the case, why is it that aggregate productivity growth rates have declined since the early 1970s at the same time that OECD economies are widely believed to be in the midst of a major wave of technological change? A large number of factors, including macro-economic performance and micro-structural developments, seem to lie behind the observed decline in TFP growth [Englander and Mittelstädt (1988)]. The following factors seem to be particularly important:

1. Lags in the diffusion of productivity gains from the "leading edge" (sometimes identified as "high-tech") industries to the rest of the economy;
2. Delays in the translation of potential into actual productivity gains arising from organisational, social and institutional factors;
3. Statistical problems in the measurement of *real* productivity because of the inability of the system to record some of the quality improvement associated with information technology, especially in the service sector;

4. The uneven pattern of technical change and the varied institutional response at national level, with consequent structural disequilibria in international trade and payments, and a slowdown of world economic growth feeding back in adverse effects on productivity.

1. Cross-sector diffusion and the pattern of productivity gains

In those sectors where new technologies have diffused most widely, productivity growth has been higher. A recent study shows that TFP over the period 1973-81 was significantly higher in high-tech sectors than in the manufacturing sector as a whole (Table 2.2), particularly in the leading industrial countries [Commission of the European Communities (1985)].

Table 2.2.

Total factor productivity in high-tech industries, 1973-1981

Average annual growth rate

	Total manufacturing	High-tech sector[a]
Belgium	2.6	2.6
Germany	1.5	2.7
France	2.0	2.4
Italy	1.7	3.8
Netherlands	1.5	0.9
United Kingdom	0.1	1.7
Europe[b]	1.4	2.6
United States	0.2	1.2
Japan	2.9	8.1

a) Electrical equipment and electronics; information technology, automated office equipment and precision instruments; and chemicals and pharmaceuticals.

b) Total for the six European countries noted above.

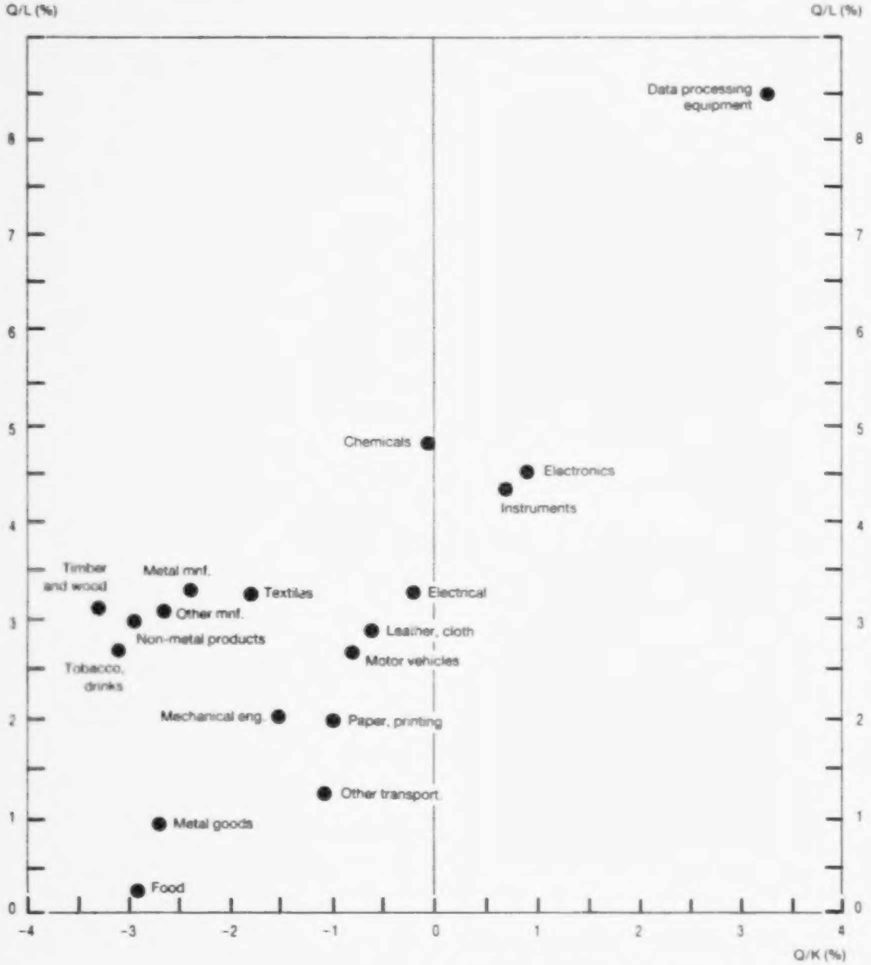
Source: CEC (1985).

The aforementioned study defines the high-tech sector as industries covering electrical equipment and electronics, information technology, automated office equipment and precision instruments, and chemicals and pharmaceuticals. However, one of the difficulties in assessing the effects of technical change in industry stems from the accuracy of such a definition. For instance, R&D-intensive industries give a very rough approximation of those areas most affected by the wave of technical change, and the aggregation of "electrical equipment" with "electronics" can be particularly misleading. While the electronic industries are undoubtedly the leading edge of the new wave of information technology, "electrical equipment" includes traditional electromechanical products with a contrasting pattern of employment, productivity, investment, R&D and output growth. Similar considerations apply to the divergent trends of various sectors of the chemical industry: fine chemicals are experiencing a period of very rapid technical change, whereas the bulk commodity chemicals sector is facing major problems of overcapacity and rationalisation.

In view of these classification problems, it seems preferable to consider here only those sectors that make the most use of information technologies, namely the computer industry and

Chart 2.1. **POST-WAR GROWTH IN LABOUR (Q/L) AND CAPITAL PRODUCTIVITY (Q/K) IN THE UNITED KINGDOM MANUFACTURING SECTORS**

(1948-1984, by SIC sector)



Q : net output;
L : employees;
K : official capital stock estimates from Central Statistical Office.
All figures are average annual growth rates.

Source: Soete (1987).

Table 2.3.

Information technology endowment of US industry

(IT capital as a share of each industry's overall capital stock)

	1950s	1960s	1970s	1985	Percentages change: 1985 vs. 1970s	
					Percentage points	Ratio
All industries	2.5	3.7	5.8	12.5	6.7	2.2
Goods-producing	1.1	1.1	2.0	6.1	4.1	3.0
Service-providing	3.3	5.2	7.7	15.5	7.8	2.0
Transportation	0.4	0.5	0.6	1.1	0.5	1.9
Rail	0.2	0.5	0.7	0.6	-0.1	0.9
Nonrail	0.8	0.7	0.5	1.4	0.9	2.8
Air	1.5	0.7	0.4	3.0	2.5	7.3
Trucking	0.5	0.5	0.1	0.4	0.3	3.7
Other	0.8	0.8	0.8	1.3	0.5	1.7
Communications	20.0	30.6	40.8	53.4	12.6	1.3
Telephone and telegraph	20.8	31.9	42.1	54.5	12.5	1.3
Broadcasting	5.7	10.6	19.9	32.9	13.0	1.7
Public Utilities	0.5	0.6	1.1	3.1	2.1	2.9
Electric	0.5	0.6	1.2	3.2	2.0	2.6
Gas and other	0.5	0.4	0.6	2.8	2.3	5.0
Total trade	0.7	0.9	2.5	11.1	8.7	4.5
Wholesale trade	1.6	1.8	4.9	22.5	17.6	4.6
Retail trade	0.4	0.5	1.1	3.3	2.1	2.9
Finance, insurance and real estate	6.1	5.7	6.0	14.4	8.5	2.4
Finance and insurance	4.1	3.5	4.7	27.3	22.7	5.9
Banks (inc. Federal Reserve)	1.7	1.9	3.9	26.3	22.4	6.7
Credit agencies	3.1	3.1	3.3	25.0	21.7	7.6
Securities brokers	2.6	3.9	8.3	31.6	23.3	3.8
Insurance carriers	6.0	4.4	7.2	38.0	30.8	5.3
Insurance agents	17.9	15.6	12.0	32.7	20.8	2.7
Investment holding companies	14.2	8.0	10.2	31.2	21.0	3.1
Real estate	6.4	6.1	6.3	9.7	3.4	1.5
Services	5.8	6.5	8.3	16.1	7.9	2.0
Hotels and lodging	0.1	0.1	0.1	1.7	1.6	11.5
Personal	2.7	9.3	13.6	11.5	-2.1	0.8
Business	5.1	7.9	10.9	28.4	17.5	2.6
Auto repair	0.6	0.5	0.2	1.5	1.3	7.6
Miscellaneous repair	0.5	0.4	0.5	2.7	2.2	5.3
Motion pictures	8.3	15.0	31.5	42.2	10.6	1.3
Amusement and recreation	5.3	9.7	12.3	19.7	7.4	1.6
Other	16.3	12.2	13.3	23.4	10.2	1.8
Health	21.2	16.0	19.2	29.5	10.3	1.5
Legal	1.9	2.9	4.0	13.3	9.3	3.3
Educational	10.0	9.5	12.2	46.8	34.6	3.8
Other	19.0	10.0	6.6	10.5	3.9	1.6

Note: Figures are averages over designated intervals and are derived from the industry-commodity capital stock matrix of the US Department of Commerce. IT capital includes office, computing and accounting machinery, communications equipment, instruments, photocopiers and related equipment.

Source: Roach (1988).

related electronic industries. Based on post-war evidence, Chart 2.1 brings together the growth rates in labour and capital productivity in eighteen industrial sectors in the United Kingdom for which official capital stock estimates are available. Growth in labour productivity is represented on the vertical axis and growth in capital productivity on the horizontal axis. What is particularly striking here is that the electronic industries are the *only* ones to show a growth in capital productivity as well as a relatively large labour productivity enhancement. While total factor productivity has continued to increase in recent years (although at a slower rate than in the 1960s) in most OECD countries, capital productivity has been declining in most sectors in many countries. Running counter to this trend is the computer industry, which offers the hope that as computerised capital equipment and relevant skills diffuse through the rest of the economy, it may be possible to realise greater gains in both labour and capital productivity. This hope rests on the fact that IT industries are the main users of their own technology (see Table 2.3).

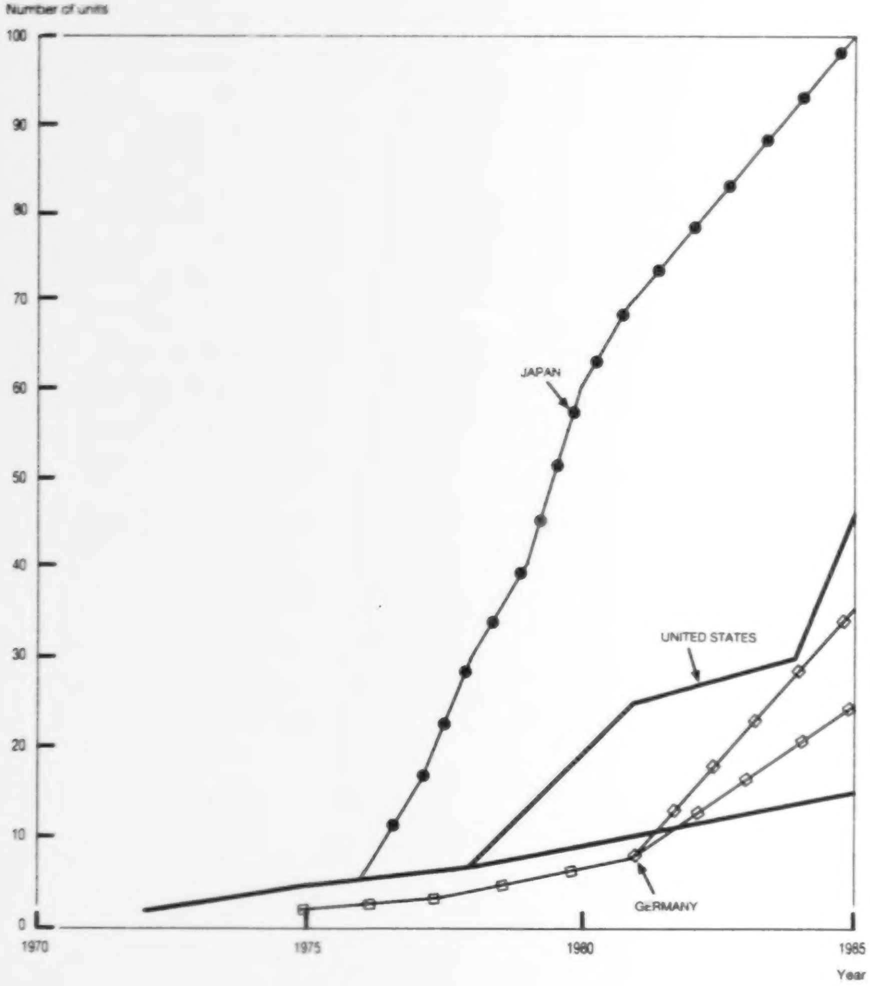
This raises the whole question of the diffusion process across sectors of the economy of pervasive technologies, such as IT. It is hardly surprising that the share of capital stock accounted for by IT products is highly differentiated across sectors of the economy. As shown by Table 2.3, information-related industries – such as telephone and telegraph – have a leading role as high-tech users. These sectors have been accumulating know-how about both hardware and software for some time, and have pools of skilled labour and competent management. Moreover, they have been investing heavily in R&D, software and new capital. Meanwhile, manufacturing and service industries that have little previous experience with this radically new technology encounter innumerable difficulties – "snarl-ups" – as they attempt to use it; the necessary skills as well as the managerial competence are simply lacking. For example, the retail trade sector has experienced only a very modest increase in the use of IT equipment despite the growing popularity of automated end-sale and inventory control equipment.

The question is one not of incremental improvements along established trajectories, but of a break with the past. In his book *The Advent of the Automatic Factory*, written in 1952, John Diebold showed astonishing foresight in this area. While others were predicting mass unemployment and deskilling due to computerised automation, Diebold pointed to the *new* skills that would be required, especially in design and maintenance. He also pointed out that computerisation involved the redesign of a whole range of products as well as processes. This would not be possible without changes in the structures of most firms, facilitating the flow of information between R&D, design, production and marketing, requiring in turn changes in the structure of management that would promote *horizontal* mobility of workers and information.

Events have proved Diebold right. Only in the 1970s and 1980s has computerised automation in the form of flexible manufacturing systems (FMS), computer-integrated manufacturing (CIM), computer-aided design (CAD), etc. really become widespread (Chart 2.2), and it still has a very long way to go.

In such a complex diffusion process it is necessary to adapt telecommunications and computer (especially software) technology to the specific needs of each sector and each enterprise. This is far from easy to accomplish. As many leading management consultants underline, it is possible to make effective use of the new "off the shelf" electronic hardware only if major organisational changes are made in the adopting firms. Lockett (1987), in his study of information technology innovations in a large multinational company, points out that a continuing dialogue between the provider and the user is a prerequisite for the successful implementation of IT innovations. An experimental R&D approach is necessary, rather than the simple installation of new equipment and relevant software.

Chart 2.2. **GROWTH OF FMS IN GERMANY, JAPAN, AND THE UNITED STATES**



Note: The two curves for Germany and the United States apply to a wider and a stricter definition, respectively, of FMS. For Germany, an interval estimate is given for the number of FMS installed at the end of 1984. Due to these definitional problems, this chart should be taken as indicating broad trends and not precise magnitudes.

Source: Ayres (1987).

This is consistent with earlier findings of innovation research in the 1960s and 1970s [Rothwell (1974)] which stressed understanding of user needs as the most important condition for successful innovations. In the case of information technology, this requirement of "user-friendliness" is exceptionally important and creates special problems. In the first place, the user often has great difficulty conceptualising and specifying the precise nature of the requirement. Secondly, the provider rarely has the possibility of understanding this requirement immediately from the outside. Thirdly, the technology itself is still extremely fluid. Finally, the introduction of IT frequently brings with it the need for reorganisation of management itself and/or production systems.

2. Organisational and social factors in moving from potential to actual productivity gains

Brief mention of an historical analogy – the diffusion of electric power – may be useful here. The key technical innovations were made between the 1860s and the 1880s. With the establishment of effective generating and transmission systems in the 1880s and 1890s (which also involved a wave of social, legal and organisational innovations), the emphasis shifted to diffusion of applications of electric power throughout the economy in both industry and households. During this phase, although technical innovations continued at a high rate and big improvements were made in the available hardware, the key problems were the organisational change in firms, modification in skills, factory layout and the attitude of engineers, managers and workers. Warren Devine (1983) has described this change in words which might also be applied to the diffusion of computerised automation:

> "Replacing a steam engine with one or more electric motors, leaving the power distribution system unchanged, appears to have been the usual juxtaposition of a new technology upon the framework of an old one... Shaft and belt power distribution systems were in place and manufacturers were familiar with their problems. Turning line shafts with motors was an improvement that required modifying only the front end of the system... As long as the electric motors were simply used in place of steam engines to turn long line shafts, the shortcomings of mechanical power distribution systems remained."

It was not until after 1900 that manufacturers began to realise that the indirect benefits of using unit electric drives were far greater than the direct energy-saving benefits. Unit drive gave far greater flexibility in factory layout as machines were no longer placed in line with shafts, making possible big capital savings in floor space. For example, the United States Government Printing Office was able to add forty presses in the same floor space. Unit drive meant that trolleys and overhead cranes could be used on a large scale, unobstructed by shafts, countershafts and belts. Portable power tools increased even further the flexibility and adaptability of production systems. Factories could be made much cleaner and lighter, which was very important in industries such as textiles and printing, both for working conditions and for product quality and process efficiency. Production capacity could be expanded much more easily. The full growth benefits of electric power for the economy therefore depended not only on some key technical innovations in the 1870s and 1880s, but also on the development of a new paradigm or production design philosophy. This involved the redesign of machine tools, power tools and many other types of production equipment. It also involved the relocation of many plants and industries, based on the new freedom conferred by electric power transmission and local generating capacity.

The analogy between electrification and computerisation helps to illustrate the long time-scales involved in any type of technical change that affects a very broad range of goods and services, i.e. where many products and processes have to be redesigned to realise the full potential of the new technology. Perez (1983) has pointed out that the dominant technologies of a particular period actually become an integrated web since they are developed and redesigned together to take advantage of specific new technical and economic opportunities, whether related to electricity and cheap abundant steel, or to electronic computers, cheap integrated circuits and universal cheap telecommunications. As the techno-economic paradigm crystallises and develops, the interrelated advantages become increasingly apparent, as does the logic of the new system. A flow of new technical and organisational innovations helps resolve the main problems and bottle-necks. But in the early stages there are great difficulties and risks in adopting the new equipment because it is not yet an integrated system, and adoption involves piecemeal trial and error – a process of learning by doing, using and interacting.

It would thus be quite unreasonable to expect sudden increases in productivity in sectors far removed from the new technology. Such increases could be expected only after a fairly long process of familiarisation and of developing customised equipment, new skills and new management attitudes and structures. These issues are dealt with more fully in Chapter 3. Here the stress is on the cross-sectoral aspect of the diffusion process, the process of learning by doing and by interacting [Lundvall (1988)] and the time-lags involved in moving from the potential productivity gains of a radical new technology system to their actual realisation.

The case of Japan is a particularly interesting one in this context. Japanese industry and the Japanese Government were quick to realise the importance of cross-sectoral diffusion of information technology [Freeman (1987)]. Apparently it was in Japan that the expression "mechatronics" was coined; in any case, a law on the fusion of mechanical and electronic technologies was passed as early as 1971. This encouraged applications of IT in mechanical engineering and other metalwork industries. Kodama (1985) attributes much of the extraordinary Japanese success in robotics, machine tools, FMS and other sectors to this "fusion" approach to new technology – an approach which has apparently also been important in service industries and in construction, accounting in part for the exceptional performance of the Japanese financial services and the growing worldwide competitive challenge of the construction industry. The availability of cheap microprocessors and of CAD systems, computer graphics and digital communication networks has greatly facilitated this type of diffusion. It is reported that large "intelligent" buildings now under construction in Tokyo have an electronic "content" as high as 30 per cent. We are long familiar with the fact that the electronic content of a fighter aircraft or a battleship may be as high as 75 per cent, or 50 per cent in the case of machining systems, but the notion of the "electronic content" of "smart" buildings or financial systems is still somewhat unfamiliar.

Of course, success stories are not confined to Japan; there are many examples from the United States and Europe. Some of the Nordic countries offer interesting cases. In the Finnish forest industry, user-producer collaboration has led to successful applications of process control instrumentation. The Swedish engineering industries have matched Japan in the production and use of robotics. A Finnish computer company (Nokia) has been one of the most successful in banking automation and also offers one of the few examples of successful competition with the Japanese (and NIC) makers of colour television sets.

These examples suggest that there is no unique national or cultural peculiarity about IT implementation, although of course national cultures do affect the nature and speed of institutional response to new technological opportunities. This point is confirmed by the experience of Japanese companies operating in the United States and in Europe. Productivity gains made in overseas plants have sometimes been almost as great as those in Japan. What is particularly striking is that these are sometimes achieved almost entirely by the introduction of Japanese management techniques, working practices and organisation – for example in the GM/Toyota collaboration at the Fremont (California) plant – rather than by new hardware.

There are, however, interesting counter-examples. Prais (1986) notes a Japanese subsidiary operating in the United Kingdom that experienced much lower productivity levels in its UK plant than in Japan, although the technology and the hardware were identical. The problem was one of lack of skills in electronic maintenance work. This illustrates the main point emphasized in this section on productivity slow-down: the translation of potential to actual productivity gains depends on a complex social process of adjustment involving training, reskilling, the combining of old and new technologies, the development of new management and organisational structures, new patterns of workforce collaboration and other social changes. The availability of new hardware and new fixed investment is an essential factor but not the only one, and should often be preceded by an intense process of training and reorganisation to get the best results. Although they are very different in some respects, the Japanese and Nordic "models" have in common an intense process of workforce involvement and consultation, together with extensive training and re-training.

3. Productivity Measurement Problems

While few doubt that there has been a real slow-down in total factor productivity growth rates throughout the OECD area in the 1970s and 1980s, it is possible that this decline is being overestimated because of defects in productivity measurement. In particular, it is possible that quality changes in the output of the service sector are not being satisfactorily incorporated within the current framework of statistics. Service output and productivity have always raised severe problems of conceptualisation and measurement [Smith (1972); Guy (1987)]. These problems are now compounded by the more rapid rate of technological change in some sectors. In the case of medical diagnostics in the health sector, for instance, the difficulties arise from applications of bio-technology, but more frequently they are associated with changes in the provision and processing of information through computerised systems and new forms of telecommunications. They concern the speed, accuracy, presentation and computation of many types of data, as well as the availability of communication networks and data banks.

The only way to deal with such productivity measurement problems is to take into account the modifications IT induces in the very nature of service activities. By introducing an element of space or time storage, information technologies increase the "tradability" of service activities [Soete (1987)]; increasingly, the process of production can be separated from consumption. Videotapes of concerts and pre-packaged interactive medical diagnostic systems are but two of the many examples.

As a consequence, the distinction between manufacturing and the service sector is becoming increasingly blurred [Rada (1987)]. It is no longer meaningful to speak of a "service" economy or a "manufacturing" economy, since these are interdependent. Thus suppliers of hardware tend to offer a "service" or at least a subsystem incorporating many service elements – an example is the "instant print shop", which is partly in retail distribution and partly in the manufacturing (printing) industry. On a much larger scale this tendency is evident in the supply of design, engineering and other information services, together with entire new plants.

4. Structural disequilibria in trade payments

The fourth possible explanation of the productivity slow-down relates to disequilibria in the international banking, payments and financial systems and their implications for slower growth in the world economy. Although productivity gains can continue to be made during slower growth and even economic recession, they are usually more difficult to attain during such periods. The Verdoorn-Kaldor law suggests that it is generally easier to achieve productivity gains in periods of rapid economic growth. There is a "virtuous circle" feedback mechanism; each reinforces the other through new investment and scale economies.

C. PRODUCTIVITY GROWTH AND EMPLOYMENT PERFORMANCE

The foregoing suggests that there is likely to be little disagreement with the view that the new technologies offer the potential of significant productivity gains. It is also comforting to observe that over the long and medium term there is a positive association between productivity developments and employment growth. Yet major worries about growing unemployment persist; they stem from two sources. First, unemployment rates over the long term have tended to rise (Table 2.4). Moreover, hours worked per person per year have significantly declined over the same period (Table 2.5). The potential for rising unemployment levels is clearly seen by some observers as the key issue to be addressed [Brunetta (1987)]. Second, there are worries that the current wave of technological change is truly without historical precedent, and that past experience is consequently not an adequate guide to the current problems of adjustment.

Table 2.4.

Unemployment as a percentage of total labour force

	1913	1950	1973	1987
France	n.a.	2.3	2.7	10.6
Germany	n.a.	8.2	1.0	6.5
Japan	n.a.	1.9	1.3	2.8
Netherlands	n.a.	2.8	3.1[a]	9.6
United Kingdom	2.1	2.5	2.2	10.3
United States	4.3	5.2	4.8	6.1

a) From Maddison (1987).

Sources: For 1973 and 1987: OECD, *Labour Force Statistics* (1988), and *Employment Outlook* (1988); earlier years from Maddison (1987).

The whole issue of full employment needs to be discussed in terms of the wider notion of the "Active Society" [Gass (1988)]. Changing economic, demographic and social structures are presenting a new set of challenges to institutions of social protection. During the post-war period of strong economic growth in which these institutions were built, an economically active part of the population was able to generate the necessary resources to finance rising standards of well-being for both active and non-active sections of society. Since then, large-scale and persistent unemployment, along with the ensuing costs of unused human

Table 2.5.

Hours worked per person per year

	France	Germany	Japan	Netherlands	United Kingdom	United States
1870	2 945	2 941	2 945	2 964	2 984	2 964
1890	2 770	2 765	2 770	2 789	2 807	2 789
1913	2 588	2 584	2 588	2 605	2 624	2 605
1929	2 297	2 284	2 364	2 260	2 286	2 342
1938	1 848	2 316	2 391	2 244	2 267	2 062
1950	1 989	2 316	2 289	2 208	1 958	1 867
1960	1 948	2 081	2 430	2 214	1 877	1 835
1973	1 771	1 804	2 195	1 805	1 688	1 754
1986	1 533	1 627	2 099[a]	1 555	1 518[b]	1 683

a) 1985.
b) 1984.
Sources: Maddison (1987); for 1960 onwards, OECD (1983, 1987).

resources, social stigma and decaying skills, has raised fundamental questions about social organisation, the role of the individual in society, and society's responsibility to the individual. Further pressures arise from demographic developments related to the ageing of populations and the increase in the number of lone-parent families, as well as from changes in individual preferences away from contentment with income support and towards a claim to active involvement in the productive system. A new and alternative model should therefore be considered: an Active Society, in which policies are designed to help as many people as possible play a positive role so that they can perceive themselves and be perceived as making a useful contribution to economic and social life. Such contributions could take newer and more varied forms than simply basic paid employment in the market. The new technologies, with their fundamental impact on the world of work, could well facilitate such a development if their introduction is accompanied by changes in work organisation, working time arrangements, and the offer of new opportunities for education and training. A common point made by analyses on the work improvement potential of the new technologies is that they indeed allow the production of goods and services to be less dependent on physical presence at the job site and on the simultaneous accomplishment of standardized and circumscribed tasks [Brunetta and Venturini (1987)]. Social innovations such as major modifications in the regulations governing the duration and timing of work should therefore be promoted in order to realise this potential.

The effects of new technologies on employment are largely conditioned by the job-generating potential of the service sector. Innovation processes in service activities seem to be characterised by a sort of "reverse product cycle" which has three stages [Barras (1986)]. It starts with process improvements to increase the efficiency of delivery of existing services. This phase may involve the shedding of labour, as for example in some of the early 1970s applications of mainframe computer technology in service organisations. The second phase involves process innovations that improve service quality. Examples of this are found in the more recent applications of mini- and micro computer technologies, which have helped to improve the quality of services such as on-line policy quotations. The third phase leads to product innovation through the generation of new types of services that are so different in nature and mode of delivery from more traditional forms that they can best be described as new service products. Examples can be found in home banking and shopping, network information services for domestic and business users, computer-aided education and training, expert systems for medical diagnosis, etc. This last phase has hardly begun, but once under way it could be a powerful job-generating force. There is already evidence of rapid growth in employment in various service areas related to information technology [Soete (1987)].

These considerations suggest that job generation will ultimately depend on many factors (including especially the rate of investment). Hence it is rather difficult to derive precise employment implications, particularly as some developments sketched above refer to the future. These views do, however, emphasize the role of growth points related to technology and the important enabling role of policies related to education, training, industrial relations and the pattern of institutional regulation.

They also point to the crucial role of policies for investment, particularly infrastructure investment. The development of the worldwide telecommunications network is the single most important element in this infrastructure, since many of the new traded information services and other new activities will depend upon the universal availability of information system networks. However, other types of new investment are essential for the renovation of capital stock on the basis of new technology. Many economists, as well as public organisations such as employers' associations and trade unions, have stressed the importance of the maintenance and renewal of the capital stock in transport, utilities, construction and other sectors where public investment often plays a big role. This could indeed help to alleviate unemployment in the inner cities, where the social problems and deprivation are most acute. Such an orientation of public investments is much different from the Keynesian type of policies from the post-war period. The task is not to stimulate investment randomly simply in order to create jobs; rather, investments should be channelled into areas that can stimulate and reinforce technical change. This by no means excludes "traditional" or "declining" industries. On the contrary, information technology offers scope for new products, processes and services in every sector of the economy.

At present, investment in both old and new industries, as well as in infrastructure, is hampered – on the one hand by uncertainties about the development of the international economy, and on the other by skill shortages and cultural and institutional inertia. The problem of international disequilibria is discussed in the following section, while the next two chapters examine the problems of work organisation and intangible investment in education. The point to be made here is that although tangible (physical) investment in machinery, buildings and equipment has always been closely related to intangible investment in knowledge and its dissemination, this interdependence takes on a new form with information technology. Investment in information systems is at the heart of the technological transformation now in progress. Contemporary business enterprises as well as governmental organisations and universities now depend upon their computerised information systems and the relevant software for their day-to-day operations and indeed future. Consequently, intangible investment in R&D, education, training, and software maintenance and development is now an essential component of overall physical investment.

D. THE PROCESS OF ADAPTATION: INTERNATIONAL AND REGIONAL DIMENSIONS

As the introduction noted, the speed and nature of this process form one of the key concerns in technology-employment discussions. New industries may spring up, and shifting demand patterns certainly put pressure on more established industries. Some regions or communities may be disadvantaged as economic activity is attracted away to other centres. At the international level, countries failing to keep up with technological upgrading may find their comparative advantage changing in an undesirable direction, with especially serious consequences in their export- and import-competing sectors.

Shifting trade patterns that are partly due to technological change can have major employment impacts on a country whose comparative advantage is thereby changed. The economic and political costs of trade-related employment losses receive greater attention when the impact on particular sectors or regions is sharper. Changes in trade of high-tech goods can be one indicator of how technology may affect international trade. This would, however, be a narrow measure, since technological change can affect a broader range of industries than simply the sectors producing high-tech goods. It was argued in Chapter 1 that some changes in technology are so pervasive that they not only generate the rise of new industries and services (and the decline of old ones) but also affect the competitive performance of many established sectors of the economy. The capacity for an adequate social and institutional response to such pervasive technical change varies greatly among countries, and inadequate response may aggravate the disequilibrating effects. While some countries may seize the opportunities presented by new technologies (as was the case with Germany and the United States in relation to electric power and its numerous applications), others who are unable to do so may be seriously disadvantaged. It seems that in the present wave of electronics-based technical change, some newly industrialising countries – such as Korea – may catch up with the industrial leaders, while other developing countries may fall further behind. Perez and Soete (1988) point out that the externalities generated by infrastructural investment and by "intangible investment" are crucial in this catching-up process.

Two new features introduced by information technologies are the accelerated international transfer of technology and greater mobility of service industries. The financial services industry is already demonstrating the far-reaching consequences of this enhanced mobility, which may affect many countries and regions.

Even more complex issues of structural adjustment are raised by patterns of trade performance. To the extent that process and product innovations do not spread evenly across countries and have a cumulative nature, a "technological" trade surplus may prove relatively unresponsive to exchange rate adjustments (see Tables 2.6 and 2.7). There is clearly an element of this in recent Japanese trade performance. Even with agreements limiting imports

Table 2.6.

Performance in manufacturing trade

	Export/import ratios		
	1965	1975	1985
OECD (Total)	1.29	1.36	1.12
United States	1.55	1.38	0.60
United Kingdom	1.78	1.29	0.90
France	1.40	1.31	1.12
Sweden	0.90	1.09	1.25
Italy	1.92	1.72	1.47
Germany	1.71	1.89	1.69
Japan	4.22	4.58	4.25

Source: Kaldor and Walker (1988).

Table 2.7.

Performance in electronics trade

	Export/Import Ratios		
	1965	1975	1985
OECD (Total)	1.26	1.22	1.02
United States	1.08	1.42	0.54
United Kingdom	1.60	1.04	0.60
France	1.11	0.95	0.71
Sweden	0.98	1.43	1.10
Italy	0.93	1.11	0.73
Germany	1.47	1.45	0.95
Japan	11.32	5.88	13.90

Source: Kaldor and Walker (1988).

of cars, television sets, Very Large Scale Integration (VLSI) and other products, and with some creeping protectionism in other areas, the Japanese export surplus in manufacturing and particularly in the electronics trade has proved remarkably impervious to exchange rate adjustments [Kaldor and Walker (1988)].

The evidence is now strong that Japanese companies have been rather more successful than most in adapting their management structures, capital stock, training systems and industrial relations to harness the potential of information technology. Other industrial countries (with the possible exception of some Nordic economies) have not shown the same flexibility; indeed to some extent, they have been the victims of their own earlier success with other technologies, which have led to rigidity and inertia. While US companies led the world in the early exploitation of radical innovations in micro-electronics, computers, telecommunications and software – the majority of these innovations originated in the United States – they have been increasingly overtaken by Japanese companies in the later stages of diffusion (except in the defence area). Japan has been particularly versatile in extending applications of IT to new sectors and in developing appropriate organisational structures (e.g. "mechatronics" and robotics) in construction and in financial services.

There is of course an even greater problem of disequilibria in relation to Third World countries, with a few NICs (especially South Korea) overtaking the established technological leaders and other countries falling further behind, unable to resolve their indebtedness problems. In so far as these severe international disequilibria have a structural-technological component, they may require a rapid transfer of technology to catching-up countries. The freest possible regime of information flows would be in the interests not only of the Third World, but also of the established technological leaders, since they also depend on healthy expanding economies in the Third World.

These major problems of structural disequilibrium confront the world economy with the necessity for novel methods of co-ordinating international trade and economic policies, for if they are allowed to get out of control the result could be a major wave of protectionism and world depression. A slow-down in the world economy engendered by these disequilibria represents by far the most serious threat to employment throughout the system.

Difficult problems are also encountered at the regional level within countries. Almost every country has its "Silicon Valley" or its "Silicon Glen" – cluster areas of new science and technology activities. Most also have their old "smoke-stack industries" in areas of relative economic decline and higher-than-average unemployment.

Most OECD countries have recognised for some time that tax incentives to locate new plants in "smoke-stack" regions are no longer the most effective form of regional development. More important are policies designed to favour the type of infrastructure that could attract the newer types of industry and to ensure an adequate supply of the skilled manpower that would be needed. There is consequently great interest in such approaches as the Japanese Technopolis project [Kuwahara (1984); Tatsumo (1987)], with its emphasis on R&D, communications infrastructure, education, and the newly expanding branches of the economy. Also noteworthy are the many recent attempts to transform old and abandoned industrial sites into "scientific parks". The modern telecommunications infrastructure is particularly important, since it enables firms in remote regions and even rural areas to have access to up-to-the-minute information and to participate in networks hitherto confined to participants in the major centres.

These examples illustrate the point that technology policy in the OECD countries can no longer be regarded as an isolated phenomenon, but must be taken into account in many different spheres of national and international policy-making: economic, defence, employment, trade and regional policies are now all heavily affected by worldwide developments in technology and their disequilibrating effects. They also illustrate the interdependence of many of these issues.

E. CONCLUSIONS

There are several possible explanations why the more recent technological advances have not made an impact on productivity growth measured at the aggregate level. While a large number of factors have been associated with declines in productivity growth, it seems that the most important of these are: *i)* lags in diffusion of new technology across various sectors of the economy, associated with the radical nature of IT; *ii)* lags in translating potential productivity gains into actual productivity gains, associated with organisational and institutional problems of adaptation; *iii)* disequilibrating effects of technical change in relation to international trade, regional development and industrial structure. It is also possible that there is some underestimation of the real productivity gains in the 1980s due to measurement problems.

The policy implications of this analysis are further developed in the Conclusions and Recommendations of this Report. Here only one main point is stressed: the interdependence of technical, economic, social and organisational change. The case of information technology shows that however good the technologies may be, the realisation of their full potential depends on a complex process of institutional change and intangible investment, and not simply on fixed capital formation. This point is developed in depth in Chapters 3 and 4. But clearly there is a major role for an international organisation such as the OECD in the international diffusion of best-practice productivity experience, a role successfully performed in the 1950s by the OECD's forerunner organisations [European Productivity Agency (EPA), Organisation for European Economic Co-operation (OEEC)] in relation to the "productivity gap" at that time between the United States and Europe.

60

BIBLIOGRAPHY

AYRES, R. (1987), *Future Trends in Factory Automation.* International Institute for Applied Systems Analysis, Working Paper No. 87-22, Laxenburg.

BARRAS, R. (1986), "Towards a Theory of Innovation in Services", *Research Policy*, Vol. 15, No. 4, August, pp. 161-173.

BRUNETTA, R. (1987), "Contribution to the Expert Group on Social Aspects of New Technologies", OECD, Paris (mimeo).

BRUNETTA, R. and VENTURINI, A. (1987), "New Technology: Work Organization and Industrial Relations", OECD, Paris (mimeo).

COMMISSION OF THE EUROPEAN COMMUNITIES (CEC) (1985), *Euroeconomy*, No. 25, September.

DEVINE, W. (1983), "From Shafts to Wires: Historical Perspective on Electrification", *Journal of Economic History*, Vol. 43, No. 2, pp. 347-372.

DIEBOLD, J. (1952), *Automation: The Advent of the Automatic Factory*, New York: Van Nostrand.

ENGLANDER, S., MITTELSTADT, A. (1988), "Total Factor Productivity: Macroeconomic and Structural Aspects of the Slowdown", *OECD Economic Studies*, No. 10, Spring, pp. 7-56.

FREEMAN, C. (1987), "The Challenge of New Technologies", *Interdependence and Co-operation in Tomorrow's World*, OECD, Paris.

FREEMAN, C., CLARK J. and SOETE, L. (1982), *Unemployment and Technical Innovation: A Study of Long Waves and Economic Development*, London: Frances Pinter.

FREEMAN, C. and SOETE L. (1987) (eds.) *Technical Change and Full Employment*, Oxford: Basil Blackwell.

GASS, J.R. (1988), "Towards the Active Society", *OECD Observer*, June-July, pp. 4-8.

GUY, K. (1987), "The UK Tertiary Service Sector", Chapter 9 in FREEMAN and SOETE, (eds.), *op. cit.*

KALDOR, M. and WALKER, W. (1988), "Military Technology and the Loss of Industrial Dynanism", *La Recherche* (forthcoming).

KATSOULACOS, Y. (1986), *The Employment Effect of Technical Change: A Theoretical Study on New Technology and the Labour Market*, Brighton: Wheatsheaf Books Ltd.

KODAMA, F., (1985), "Mechatronics Technology as Japanese Innovation: A Study of Technological Fusion", Graduate School for Policy Science, Soitama University, Tokyo.

KUWAHARA, Y. (1984), "Creating New Jobs in High Technology Industries". Paper prepared for the OECD inter-governmental conference on employment growth in the context of structural change, Paris (mimeo).

LOCKETT, M. (1987), "The Factors Behind Successful IT Innovations", Oxford: Templeton College (mimeo).

LUNDVALL, B. (1988), "Interaction as an interactive process: from user-producer interaction to the national system of innovation", in G. DOSI *et. al.* (eds.), *Technical Change and Economic Theory*, London: Pinter Publishers.

MADDISON, A. (1987), "Growth and Slowdown in Advanced Capitalist Economies: Techniques of Quantitative Assessment", *Journal of Economic Literature*, June, pp. 649-698.

NELSON, R. (1981), "Research on Productivity Growth and Productivity Differences: Dead Ends and New Departures", *Journal of Economic Literature*, September.

NELSON, R. and WINTER, S. (1982), *An Evolutionary Theory of Economic Change*, Cambridge, Mass.: Harvard University Press.

OECD (1983), *Employment Outlook*, Paris, September.

OECD (1987), *Employment Outlook*, Paris, September.

OECD (1988), *Employment Outlook*, Paris, September.

PASINETTI, L. (1981), *Structural Change and Economic Growth: A Theoretical Essay on the Dynamics of the Wealth of Nations*, Cambridge, England: Cambridge University Press.

PEREZ, C. (1983), "Structural Change and the Assimilation of New Technologies in the Economic and Social Systems", *Futures*, Vol. 15, No. 5, pp. 357-375.

PEREZ, C. and SOETE, L. (1988), "Catching Up in Technology" in G. DOSI *et al.* (eds.), *Technical Change and Economic Theory*, London and New York: Pinter Publishers.

PRAIS, S.J. (1986), *Educating for Productivity: Comparison of Japanese and French Schooling and Vocational Preparation*, London: National Institute of Economic and Social Research.

RADA, J.F. (1987), "Information Technology and Services", in O. GIAVINI, (ed.), *The Emerging Service Economy*, Oxford: Pergamon Press.

ROACH, S. (1988), "Technology and the Service Sector: America's Hidden Competitive Challenge", (mimeo).

ROTHWELL, R. *et al.* (1974), "Sappho Updated: Project SAPPHO Phase 2", *Research Policy*, Vol. 3, No. 3, pp. 258-291.

SMITH, A. (1972), *The Measurement and Interpretation of Service Output Changes*, London: National Economic Development Office.

SOETE, L. (1987), "The Newly Emerging Information Technology Sector", Chapter 10 in FREEMAN and SOETE (eds.) (1987), *op. cit.*

TATSUMO, S. (1987), *The Technopolis Strategy*, New York: Prentice Hall.

Chapter 3

FLEXIBILITY IN THE WORKPLACE

A. INTRODUCTION

This chapter considers the implications of the information technologies in relation to two central issues: work organisation and industrial relations. Although it is common to think in terms of the effects of IT upon each, the reverse direction of causality is also discussed.

Controversy has surrounded the effects of IT upon the way work is performed, notably the skill required of employees and the scope provided for task activity. On the one hand, new technology has been welcomed for the prospect of work's redemption from a history of drudgery and degradation. On the other, IT has been seen as actually intensifying drudgery and degradation. Section B finds that a wide range of outcomes is already visible, with an overall tendency towards upskilling, while managerial attitudes and objectives are proving the key factor in determining the direction of change.

At the same time, rigidities in work organisation are a serious constraint upon the effective utilisation of new technology, and appear to be the reason why productivity gains achieved from IT implementation have often fallen short of both expectation and technical potential (see Chapter 2). The experiences of those enterprises that have already put IT to good use make it clear that innovative systems of work organisation, altered managerial attitudes and skills and new approaches to employee capabilities, as well as improved education and training, are all essential to effective innovation. These issues are discussed in Section C.

The second area of interest is industrial relations (IR). IT means change. Tendencies towards smaller-scale production, more flexible utilisation of labour and a greater information/service sector share in employment require major adaptations on the part of trade unions. Conversely, IT could encounter a variety of receptions from IR institutions, ranging from outright employee resistance through detailed bargaining over methods and outcomes to unilateral management implementation. The procedural and substantive issues arising from the introduction of IT are discussed in Section D.

B. INFORMATION TECHNOLOGY AND THE CONTENT OF WORK

The effects of information technology upon work involve changes in the skills required of, the autonomy permitted to, and the interest generated in the employee by the job. Outcomes depend upon two key factors: firstly, the implications of IT for the tasks left to human intervention within production processes; and secondly, the ways in which altered work tasks are combined into jobs. This section deals with both factors and their implications for the occupational structure of employment as a whole.

1. New technology and work tasks

New technology exerts an effect upon the production tasks remaining for humans at two levels: the level of the individual machine and the level of machine co-ordination. Important changes result at each level in both factories and offices.

In the factory, the microprocessor-based control equipment generally extends the range of functions of individual machines, as well as the speed and accuracy of their operation, while requiring less (in the case of robots, zero) manual intervention by the machine operator. More dramatically, there are the process control options opened up by the use of central computers and telecommunications to co-ordinate the activities of the computerised machines themselves. The use of programmable logic controllers to link a set of computer numerical control (CNC) machine tools, automatic insertion equipment, robots and transfer devices into a flexible manufacturing system (FMS) has extended the influence of the new technology across physical production processes. Similarly, information generated by computer-controlled systems can be fed directly into inventory control, purchasing and sales.

Thus the production methods of a wide range of manufacturing firms now resemble those already established in the classic process technologies (petroleum, steel, etc.), where human intervention is not only less extensive but also changed in content. The requirements are no longer experience and dexterity, but technical knowledge and vigilance. This change is particularly striking in small batch production, which previously involved extensive manual intervention by skilled workers.

Computerised integration of functions can extend to the vertical dimension as well. Computer-aided design and manufacturing (CAD/CAM) systems integrate design, drafting and production into a common data network. Similarly, the operating details of particular departments can be processed directly into corporate information networks to provide access to a wide range of data for both managers and the shop-floor. Some US manufacturing firms provide data terminals in all areas of the plant and train all production workers to use them to gain access to blueprints, quality results, etc.

In the office, the versatile and productive microcomputer replaces both the typewriter and the calculator/mainframe computer for the processing of text and data respectively. Again, however, it is the networking opportunities that prove particularly important. Telecommunications linkages between individual machines permit the transmission of text, messages and data at high speed. The need for a variety of human interventions to perform data-handling, previously the province of messengers, clerks, cashiers and telephonists, is correspondingly reduced or eliminated. The technical feasibility of grouping the remaining previously separated tasks of data-coders, keypunchers, analysts and adjusters is markedly improved.

New technology changes work tasks at the top of the corporate hierarchy as well. Worldwide data networks increase the complexity of managerial work tasks by extending the range of data available while reducing the amount of data compilation required. The use of IT increases substantially the internal transparency of the company [Rada (1986)]. Increased rapidity of process and product change intensifies the demands upon managerial responsiveness.

A substantial proportion of factories and offices has already been affected by new technology. A 1982 survey of Japanese manufacturing plants found that 59 per cent had already installed at least one item of computerised production equipment [Okamoto (1983)]. The British economy has been slower to adopt IT, but even there by 1984 more than one half of all manual labour (and three quarters of "nonmanuals") functioned at workplaces which had been affected by advanced technical change within the previous three years [Daniel (1987)].

2. Job design around new technology

What happens to work organisation as a result of changes induced by new technology in the remaining human tasks depends on the way in which these tasks are grouped into jobs. The key determinant of job design is managerial policy and practice, and their two distinct objectives: efficiency and control. These motives can improve organisation performance but they do so in different ways and with mixed implications. This section discusses the forces that lead managers to design work around new technology in ways that utilise skill and encourage autonomy to different degrees.

Most organisations structure work around hierarchical control and the subdivision of labour – a pattern traditionally interpreted in terms of hierarchy and subdivision contributing to both operational efficiency and control over employees. Taking efficiency first, subdivision of labour may effect improvement by reducing training costs, lowering the costs of transferring between job tasks, and facilitating mechanisation. The constraints upon task subdivision from the efficiency standpoint arise from two sources: the size of the market, with small firms, product variability and market instability making it more costly to organise production around narrow jobs and intensive supervision; and worker desires for variety and autonomy on the job.

The motive of control exerts a conceptually distinct influence upon the organisation of work. Given the divergence of perceptions and interests between the owners/managers of the organisation on the one hand and its employees on the other, the former face the problem of eliciting compliance with organisational objectives on the part of the latter. The traditional method of seeking an alignment of objectives involves hierarchical control and task subdivision. Narrowness of job assignments, combined with clear monitoring of worker performance and effective incentives and punishments, constitutes a transparent and well-tried mechanism for the control of employees – frequently labelled Taylorism in view of its prominent position in Frederick Taylor's approach to "shop management".

Subdivision of labour has its limits as a means both of hierarchical control and of efficient operation. Taylorist techniques have often proved defective in the face of worker response, both individual (absenteeism, turnover) and collective (bargaining). One managerial response to such failings has been to reduce the intensity of hierarchical control and job fragmentation, adopting strategies of "normative control" that seek to elicit compliance by providing enhanced autonomy, skill, job security and promotion prospects to employees. In the useful distinction suggested by Fox (1974), compliance is sought by diffusing the "high trust" characteristics of work in managerial and professional echelons down into the lower reaches of the hierarchy, in place of the "low trust" which is both reflected in and fostered by Taylorist methods. Non-Taylorist strategies of motivation and control are fairly common in the internal labour markets of large international corporations, as well as in the techniques of job enrichment, work teams and quality circles with which many enterprises have experimented in recent years.

3. New technology and the menu of choices

An impressive variety is already visible in the ways in which information technology has affected work organisation. Although a wide range of conclusions can be found in the literature on IT and work organisation, one theme unites practically all of the more sophisticated studies: there is no unique implication of new technology in this domain, whether for the elimination or enrichment of skill, the intensification or alleviation of hierarchical control. This consensus view is expressed by the EC's Forecasting and Assessment in the field of Science and Technology (FAST) Programme report in terms of a "fairground" of possible outcomes [Commission of the European Communities (1982)]; by Bessant (1983) in terms of a "design space" around IT; and by d'Iribarne (1982) in terms of the "plasticity of social implementation" of new technology.

The heterogeneity of outcomes represents in turn the variety of ways in which IT affects the efficiency and control factors underpinning managerial choices. A simple diagram (Chart 3.1) can be used to represent four possible links between IT and work organisation, operating through the intermediary influences of efficiency and control [Eliasson and Ryan (1987)]. In each of these two dimensions, some attributes of new technology favour non-Taylorist outcomes while others contribute to the maintenance or intensification of Taylorism. The four categories – and evidence of their relative importance in practice – are discussed below.

Chart 3.1. **POSSIBLE EFFECTS OF "IT" ON SKILL MIX WITHIN A GIVEN JOB STRUCTURE**

		Skill requirements	
		Reduced	Increased
Factors affecting task subdivision	Efficiency	A	C
	Control	B	D

a) *Efficiency*

A widespread first impression of IT involves the deskilling of work, in that it enables the building of worker knowledge and skill into the computer, whether as hardware or software. The evaluative and decision-making powers of the microprocessor, combined with its flexibility and low price, make it potentially economical to reduce the need for human intervention in a wide range of jobs whose skill requirements have been downgraded by new technology [US Department of Labor (1977), (1979*a*), (1979*b*), (1982)].

IT may also foster deskilling on efficiency grounds even when it involves a greater capital cost than did the displaced technology. Higher capital costs provide an incentive to arrange for "dedicated" usage through the training of a specialised subset of employees so as to increase equipment utilisation and lower production costs. Examples can be found in word processing and CAD equipment [Buchanan and Boddy (1982); Long (1984)].

However, to expect IT to promote Taylorist and low-skill modes of work organisation in general on grounds of efficiency is implicitly to adopt an unrealistic assessment of technical possibilities. Even apparently routine jobs often prove, if only after the event, to require human ingenuity and initiative. Box C in Chart 3.1 can be filled with examples of Tayloristic applications of IT which have backfired and led to a reversal of strategy. A French bank which attempted to circumscribe its tellers' work with narrow task content, as part of the computerisation of front-desk procedures, found that many transactions involved anomalies and generated customer complaint; consequently, it reversed its strategy, broadened job tasks and encouraged greater autonomy in the use of terminals [Adler (1983)]. Other financial service firms have from the outset found it more efficient to use interactive computing facilities; these provide more immediate, personal and effective service to clients in conjunction with account representatives whose jobs contain a breadth of skill content and a degree of autonomy unimaginable under the preceding centralised batch processing regime, with its segregated armies of coders, keypunchers and typists [Guiliano (1982)]. The use of new technology to maintain or increase skill requirements and discretion on the job has been favoured by managers in a variety of other contexts, including lens-grinding [Wilkinson (1983)], pet food processing [Dickson (1980)] and FMS operation [Gerwin (1982)].

Clearly, management faces a choice of strategy in the implementation of new technology – whether to make the machinery as self-adjusting as possible and use personnel with limited skills, or to recognise the limits to machine intelligence and automation and use workers with greater understanding of process and product. High capital costs can encourage as well as discourage skill-intensive modes of utilisation. The greater the cost of the equipment, the greater the cost of down time and the likelihood that unit costs will be lower under the skill-using strategy. Examples are commonly found in the multi-skilled roles that management has increasingly sought to create among both production and maintenance workers in automated manufacturing [UK Engineering Industry Training Board (1981); Sorge *et al.* (1983); Ray (1984)]. When equipment and materials are valuable, higher skill in the workforce need produce only a moderate saving in down time to offset the training and recruitment costs involved relative to those for less skilled labour.

In any event, equipment embodying new technology reduces capital requirements much more frequently than it raises them (especially per unit of output; see Chapter 2). In such cases, although the propensity to dedicated modes of utilisation is reduced, so too are the incentives to develop a high technical level in the workforce. Skill-utilising strategies are thus less likely in sectors where capital requirements remain low or are reduced by new technology, such as textiles, clothing and footwear.

b) *Control*

New technology provides incentives to managers to redesign jobs with a view to employee motivation and control as well. Intensified hierarchical control (Box B in Chart 3.1) is promoted by the great increase in the availability of information about organisational activities that IT makes possible. More information about the activities of workers can be provided by electronic records of machine activity (e.g. CNC down time, cash register activity), personnel whereabouts and system performance (e.g. frequent operational statistics), thereby providing managers with more hierarchical leverage over subordinates.

The contribution of IT to supervisory control is marked when employee activities can be monitored without the employee being aware of it. In sectors where previous technology made close supervision costly, new technology may prove particularly attractive. In the United Kingdom, computerised coal-mine operations have been designed so as to provide managers above ground with enhanced information about down time underground with a view to cutting down the autonomy of face-workers, particularly in terms of initiating delays. Similarly, IT reduces the skill status of a range of manual jobs [Burns *et al.* (1983)]. A nonmanual parallel is provided by debt collections in a large US retail corporation, where the working methods of one energetic collector were built into a computer, which greatly reduced collector discretion. Management claimed that this Tayloristic implementation of new technology had improved control as well as efficiency, permitting "tighter lock on the collector" alongside of the recruitment of less qualified workers [Zuboff (1982)].

The centrality of the control issue is well illustrated by a case of conflicting modes of utilisation of IT in a British public hospital. The control over work organisation exercised by senior professionals led to the adoption of computer diagnosis – not as a substitute for professional skills but as a complement, with specialists reserving its use for themselves. In contrast, another innovation, automated biochemical testing, was implemented in a deskilling mode, restricting the relevant technicians to testing rather than enhancing the content of their jobs [Child *et al.* (1984)].

However, as in the case of efficiency, there are countervailing forces that have led other managements to use IT in ways which reduce the intensity of hierarchical control and increase employee autonomy. Technological promise is commonly belied by reality, in terms of tighter external control as well as skill displacement. The well known motivational deficiencies of Taylorism may equally affect new technology. In the debt collection example, control objectives were partly frustrated by employee falsification of performance data, while collector dissatisfaction with more regimented work resulted in an annual turnover rate in excess of 100 per cent – a level of employee discontent which providers of other service functions (less able to ignore public goodwill) would not tolerate.

The control potential of new technology may also be frustrated by playing around and sabotage, particularly by employees whose abilities are underused as a result of strict control. The efforts of hackers and IT "virus" producers has attracted increasing concern. Furthermore, there is the possibility of collective action to negate managerial plans, considered in Section D below. The upshot is that as long as some managers recognise the possibility of employee reactions impairing the control potential of new technology while others prefer to seek compliance through a high-trust strategy in the first place, there will be no general use of new technology to intensify hierarchical control.

The variety of ways in which IT is utilised across the four categories in Chart 3.1 reflects the heterogeneity of its effects upon managerial motives in job design. The factors that determine outcomes in particular cases include:

- The associated change in capital intensity in operations;
- The technical feasibility of reducing human intervention without damaging the quantity and quality of output;
- The reliability of IT-based equipment;
- The nature of control over work, hierarchical or collective;
- Managerial philosophy and strategy, Taylorist or otherwise.

Thus the range of possible outcomes is large, and managerial policy is of central importance.

An "agnostic" view on IT-related tendencies in work organisation is, however, inappropriate on two counts. The first concerns the way in which IT affects the technological menu. It is common for IT not only to extend the length of the menu but also to do so in ways that encourage autonomy and the utilisation of skills. This is especially true in data processing, where the decentralised options grafted by the microprocessor onto centralised mainframe systems have increased the range of work organisation by making clerical autonomy a cost-competitive option [Crompton and Reid (1982); Barras and Swann (1983)]. Similarly, in the numerical control of machine tools, computerisation has made editing at the machine possible and promoted skill-intensive job design.

In the competition for managerial favour, innovative, matrix-structured organisations are gaining the edge on their more traditional (hierarchical, division-based) rivals, thanks to the extended range of options offered by CAD/CAM and FMS production systems [Brödner (1987)].

Finally, there is survey evidence indicating the frequency with which cases fall into the various categories in Chart 3.1. Data from the United Kingdom are again particularly valuable. Given the widespread inclination of management towards Taylorist methods, that country might be expected to have one of the least skill-using environments for IT application. Yet only a small minority of British installations have been accompanied by reductions in skill and autonomy. In the great majority of cases, job requirements either remained unchanged or (particularly in terms of skills in nonmanual jobs) increased. Only in work pace and freedom from supervision did the overall picture of enriched jobs fail to find support, and even there the typical situation was "no significant change" (Table 3.1). These findings reflect the perceptions of managers. Union officials hold similar views, however; if anything they suggest more widespread increases in skill and responsibility requirements than do managers.

Table 3.1.

Managers' accounts of the impact of advanced technical change upon jobs

Percentages

Direction of change	Job interest	Skill	Range of activity	Responsibility	Pace of work	Supervision
Manual jobs						
More	46	42	38	33	22	16
No change	40	42	46	54	48	64
Less	11	15	15	12	28	19
Not stated	3	1	1	1	2	1
Nonmanual jobs						
More	60	55	59	39	34	10
No change	27	39	29	55	45	70
Less	5	2	8	2	16	17
Not stated	8	4	4	4	5	3
Change score	+120	+110	+110	+80	+40	+10

Source: Daniel (1987, Tables VII.2, VII.5.)

4. Changes in occupational structure

The effects of new technology upon the tasks remaining for human intervention, combined with the tendency towards skill-using modes of implementation, promise continued upgrading in the occupational structures of workplaces. Two routes are involved: changes in the importance of different occupations, for workplaces of given size; and changes in the size distribution of workplaces.

The first route reflects the potential of IT for automating the tasks of the least complex jobs at the fastest rate. Even those who set no limit to the ultimate complexity of IT-based systems must concede that in practice, applications inevitably begin with the less complex tasks. The short-term labour-saving effects of IT are therefore slanted towards less skilled jobs in factory and office alike. Thus new technology continues the long-standing automation of the work of assemblers, labourers, packers and other members of the less skilled industrial workforce. Compositional changes are expected to be even more dramatic in the white collar area, where the vast increase in the productivity of information-handling is expected to lead to reduced employment shares for less skilled clerical employees. Thus, in both manual and nonmanual work, IT acts as a substitute for labour which is low skilled and a complement to that which is high skilled [Eliasson (1981)].

A counter-tendency to occupational upgrading is present, however: declining shares for middle managers. The organisational requirement for the part of their services that involves compiling of information for decision-making by top managers can be reduced drastically by corporate information networks. The prospect of a reduced role is likely to be resisted and, to the extent that the resistance succeeds, the result will be a less thorough, less effective form of implementation. None the less, such resistance is likely only to slow, rather than to reverse, the tendency towards a decline in the numerical importance of middle management.

Compositional upgrading could be intensified by changes in the size distribution of workplaces. A central effect of IT is to improve the terms on which small-scale production competes with mass production, as sophisticated machining equipment and inventory control systems permit rapid and frequent changes of product in small batch processes. Such changes are especially evident in machine tools and textiles; the number of small firms using highly skilled workforces to turn out specialised products is rapidly growing, particularly in Italy [Brusco and Sabel (1981); Piore (1982*a*, 1982*b*)]. In the United States, small firms have proved more successful at generating new IT-based processes and products than have their large competitors; even within large enterprises, IT has already promoted the decentralisation of production to smaller plants.

The effect of these forces is that "the shape and structure of occupations is likely to change from the conventional pyramid, with large numbers of unskilled and semiskilled workers at the bottom, to something more resembling an orange or an onion...in which a bulge occurs at the middle level of skill" [Bessant *et al.* (1981)]. Other popular pictures of the emerging shape of occupations involve diamonds or even cones.

However, any occupational upgrading that accompanies new technology is subject to some key constraints. Firstly, even within industry, the effects of the first wave of computerised automation in the 1960s proved ambiguous. While upgrading did indeed accompany computerisation, it proved neither more rapid in sectors undergoing computerisation than in industries unaffected by it, nor indeed more rapid than in the same sectors during the previous decade [Eliasson and Ryan (1987)]. As the current wave of process automation permits more flexibility and decentralisation of control than did the one preceding, it may be that this time around, upgrading will be emphatic. However, the fact that similar predictions were made on the earlier occasion rather dampens any bold certainty.

Secondly, both the extent to which new technology is adopted and the degree to which human intervention is designed out of work depend upon factor prices as well as technical potential. The continuing availability of a supply of low-wage, secondary labour retards both developments in sectors such as clothing and textiles. The Japanese economy is particularly prone to dualistic outcomes as a result of the enormous disparity between the job rewards attained by the privileged minority who work for the large enterprises and what is offered the excluded majority. The major exception is Sweden, where low intersectoral pay differentials have discouraged the survival of "low-tech", labour-intensive production methods.

Finally, the growth of the service sector brings with it mixed implications. On the one hand there are the information and knowledge occupations, with their high skill requirements. Table 3.2 shows the high growth rates that have characterised professional and technical occupations in recent years. Indeed, between 1960 and 1980 in the United States, the rate of employment growth for information-related occupations was nearly triple that for other occupations [Wolff and Baumol (1986, Table 1)]; this rapid growth was associated with a marked increase in both the educational requirements of jobs and the educational attainments of workers [Ryan (1987)]. Such trends are likely to intensify in view of the rapid diffusion of IT and the technical obstacles to high rates of productivity growth in the "knowledge" component of computerised systems [Baumol, Blackman and Wolff (1985)]. Not surprisingly, information work features prominently in predictions of rapid occupational growth in advanced economies (Table 3.3).

On the other hand, there is the wide range of services which are likely to remain both relatively unaffected by IT and relatively unskilled. Thus the US Bureau of Labor Statistics forecasts rapid employment growth in such occupations as truck driving and catering as well as technical work. Several of these occupations feature alongside of IT-related work in the rapidly growing category in Table 3.3.

To the extent that rapid productivity growth holds back job creation in offices and factories while public policy prevents an expanded provision of public services, the main prospects for employment growth may well lie in personal services. In such a scenario, the tendency towards occupational upgrading within industry and business services would be considerably diluted, possibly even reversed. However, it is within industry and nonpersonal services that occupational structures stand most clearly to be upgraded in association with new technology. In fact, past experience suggests a high probability of occupational upgrading in the economy as a whole.

C. WORK ORGANISATION AND THE UTILISATION OF INFORMATION TECHNOLOGY

The preceding section suggests that implementation of new technology tends on balance to enhance employee skill and autonomy. Some corporations, notably IBM, have long favoured such forms of work organisation. Nevertheless, in an important minority of applications, management has used IT to intensify hierarchical control and task fragmentation. Such responses can reflect a realistic pursuit of efficiency under particular conditions – as for example when the organisational scope of innovation is limited, capital cost low, equipment reliability high, workforce interest low and computerised monitoring effective. Electronic checkout systems in small retail outlets are an example.

In other cases, Taylorist responses reflect not a well-considered strategy but an ad hoc continuation of traditional practices, and sometimes even the pursuit of hierarchical control for its own sake. If skill requirements then rise, it is only as a passive result of technical change.

Table 3.2.

Annual growth of employment by major occupational groups

Per cent

Major occupational groupings	Australia	Canada	Finland	Germany	Japan	Netherlands	Norway	Spain	Sweden	United States
	1978-85	1976-86	1977-86	1976-84	1976-86	1977-85	1975-85	1976-86	1976-84	1976-86
0-1 Professional, technical and related	3.4	2.9	3.7	2.5	3.7	3.7	4.6	2.7	2.9	2.5
2 Administrative and managerial workers	3.0	8.1	5.7	1.4	-0.1	4.6	6.3	-0.5	2.7	3.0
3 Clerical and related workers	2.2	1.5	1.6	0.1	2.2	1.0	1.4	0.0	0.7	1.2
4 Sales workers	1.8	0.9	2.5	1.2	1.6	0.9	1.4	-0.1	0.1	9.0
5 Service workers	1.7	3.1	1.6	1.0	1.2	2.6	1.7	1.3	1.7	1.9
6 Agricultural, animal husbandry and forestry workers, fishermen and hunters	1.4	0.2	–1.5	–1.6	–2.6	–0.5	–1.5	–4.1	–1.9	1.9
7-9 Production and related workers, transport equipment operators and labourers	-0.1	0.5	0.1	-0.4	0.8	–1.8	–0.7	–2.2	–1.6	0.4
Total employment	1.5	2.1	1.5	0.4	1.1	0.9	1.3	–1.2	0.5	2.1

Source: ILO, *Year Book of Labour Statistics*, 1986 and 1987.

Table 3.3.

Reports of national experts on fastest growing and declining occupational groups in the early 1980s

Country	Fastest growing occupations	Fastest declining occupations (or slowest growing)
Australia	Professional, technical, related and clerical workers; retailers; managers and self-employed.	Labourers; textile workers; metal and electrical production-process workers; and agricultural workers.
Austria	Certain agricultural jobs; service jobs.	Manufacturing jobs; miners; textile workers; foundry workers.
Canada	Food preparation and food services workers; communication workers; electrical machinery repair workers; technicians and technologists.	Certain engineering jobs and lower-skilled jobs that have become more complex. Miners and other workers in mineral extraction; garment, footwear and textile workers; clerical workers who are not using information technology.
Denmark	Construction workers, private sector service workers.	Public sector service workers; administrative occupations; agricultural workers.
Finland	Skilled technical workers; human service workers.	Agricultural workers, machine operators and other "industrial occupations".
France	Clerical workers; retailers; medical and social service workers; managers.	Labourers; unskilled workers.
Germany	Research, training, management and other white collar administrative jobs based on information technology; machine repair and maintenance.	Office workers who are not using information technology; transportation of goods; installation and repair of manufacturing equipment.
Greece	Agricultural workers; computer-related occupations; para-medical workers; tourism occupations; construction workers.	Public service workers.
Ireland	Professional/technical and clerical workers.	Agricultural workers.
Italy	Business services occupations; retailers.	Agricultural workers.
Japan	Professional and technical workers; retailers; and clerical and related workers; labourers.	Miners; agricultural workers.
Netherlands	Managing personnel in administrative functions; directors and managers in trade; statisticians, computer scientists; foremen.	Craft and industrial skills not specified; wood workers, furniture makers; brick layers, carpenters; shoe repairing, leather working; independent traders (excluding retail trade).
Norway	Public administrations; chemical workers; teachers; medical care workers; clerical workers using information technology.	Textile workers; agricultural, forestry workers fishers; clerical jobs other than typing and not using information technology.
Portugal	Plastic and rubber workers.	Painters; carpenters.
Spain	Highly-skilled service workers; hotel managers; public services, safety and protection workers; retailers.	Manufacturing workers, especially textile workers; low-skilled administrative workers.
Switzerland	Middle-level office workers; medical service and health workers; managerial workers; teachers; low-level service workers.	Professionals with low levels of qualifications.
Turkey	Service workers; production workers.	Agricultural workers.
United Kingdom	Highly-qualified service workers; managerial and administrative workers.	Craft workers and low-skilled industrial workers.
United States	Technical and professional occupations in the medical and computer fields such as medical assistants, physical therapists, podiatrists, and computer programmers.	Private household workers; agricultural workers; machine operators (manufacturing, especially). administrative support, including clerical.

Source: Data developed by the Secretariat.

In such cases, the ongoing organisation – particularly the structure, attitudes and strategy of management – imposes a severe constraint upon the use of IT. As such modes of implementation appear extensive, organisational inertia may account for much of the gap between potential and actual productivity gains in the use of new technology (see Chapter 2). The quality of the human resources present in an organisation (and an economy more generally) exerts a crucial influence upon both the speed of adoption of IT and the degree of success attained in its utilisation.

Another major innovation factor meriting some discussion is the utilisation of managerial resources. Several examples of successful implementation of new technology are provided by large Japanese corporations, with their marked commitment to the development of employee skills [Ball (1979); Hayes *et al.* (1984)]. Substantial resources are typically devoted to the planning and implementation of new technology [Okamoto (1983)]. In one outstanding example, 100 000 employee hours were devoted over two years (the equivalent of fifty full-time employees) to the design and preparation of an eighteen-machine FMS installation [Arnold (1983)]. The Japanese approach has been labelled "participative integrated innovation", while the Japanese themselves have developed terms such as "orgware" and "social software" to express the synthesis of technical, organisational and human considerations they seek in implementing IT [Shimada and MacDuffie (1987)].

Some Swedish firms have consciously imitated the holistic Japanese approach. The adoption by Alimak of an American CAD/CAM system and a Japanese CNC machine tool system was implemented with a long time horizon; a specific and stable team of managers, engineers and key workers; and an explicit commitment to recasting old methods of skill development and utilisation. A key difficulty was to reconcile the various assumptions about work organisation and skills which underlay the US and Japanese technical systems [Ford (1986)].

Many firms, however, come up with ad hoc and unplanned responses to the adoption of new technology. In extreme cases all that is sought is a quick "technical fix". In the United Kingdom, when plans are produced, they often suffer downgrading under pressure for rapid implementation [Rothwell (1984)]. Moreover, even when they imitate Japanese manufacturing methods explicitly, British firms typically fail to accompany them with parallel and essential organisational changes.

It has become clear that successful use of such advanced forms of new technology as CAD/CAM, FMS and corporate information systems is promoted by the recasting of methods and procedures, such as the shift from simple hierarchy and divisional organisation towards the complex, multilinked matrix type of organisation [Winch (1983a)]. Teamwork is essential, for no individual has sufficient knowledge to analyse adequately all the information [Rada (1986); OECD/CERI (1986, 1988)]. The demands upon management competence and creativity are great. A study of CAD concluded that "management learning is more complex (than that of operators) and crucially affects the rate of operator learning" [Arnold (1983)]. More generally, Blumberg and Gerwin (1981) have concluded from a three-country comparative study that the attention paid to organisational change consequent upon IT innovation is commonly inadequate relative to that devoted to the technical change itself. Similarly, a survey of the managerial impact of IT in the offices of eleven transnational corporations found that few had gone beyond simply increasing clerical productivity to analysing and optimising corporate information resource as a whole [Rada (1986)].

A further difference concerns the training, orientation and culture of management. In Japan and Germany, the training of managers is based on a strong engineering foundation, in contrast to the priority of accounting, finance and liberal arts in the United Kingdom. Moreover, management activity is organised in Japan and Germany so as to involve both low staffing of non-line departments and the rotation of managers between staff and line functions; the result is both a counter to departmental parochialism and the integration within individual managers of marketing, production and finance perspectives, leading to a more effective usage of the crucial engineering skills [Lutz (1981)].

These differences in managerial preparation and culture are particularly important in the case of sophisticated IT systems. A strong technical background and a broad conceptualisation of the organisation are required for managers to appreciate the potential of new technology [Rada (1986)]. The inadequate assessment and defective implementation of new technology by some British and French firms – in contrast with their German equivalents – reflect more parochial managerial perspectives and myopic decision criteria [Sorge and Warner (1980)]. In particular, the organisational diffuseness and long-term nature of the advantages of new technology mean that much of the benefit evades capture by standard cash flow analyses, leaving accounting- and finance-dominated firms at a disadvantage relative to their product- and engineering-oriented rivals [Frohman (1982); Gold (1982); Senker (1984)]. In addition, stock-markets – with their insistence upon short-term profitability – play a weaker role in corporate finance in Japan and Germany than elsewhere [Rada (1986)]. Finally, the more hierarchical and bureaucratic attributes of French enterprises (compared with German firms) prove particularly ill-suited to the needs of advanced technological change [Maurice, Sellier and Silvestre (1984)].

It is therefore less than surprising to find in comparing Japan and the United Kingdom that Japan leads not only in the rate of installation of new technology, but also (and perhaps even more importantly) in the rate of successful utilisation, which has proved so low in early robotisation projects in the United Kingdom as to have discouraged subsequent innovation [Fleck (1983)]. The difference shows up in productivity growth, with the gap between the high-tech sector and other manufacturing much greater in Japan than in the United Kingdom (and other advanced economies; see Table 2.2.)

A final managerial attribute of relevance to successful innovation takes the discussion back to the issues of the first section of this chapter. Even in the many cases where efficiency and motivation are actually maximised by organising work around new technology in a way that utilises skill and fosters discretion, visions of gains offered by Taylorist alternatives may yet persist. It takes a sophisticated management to differentiate between promise and reality and avoid the manifest appeal of the low-trust approach. And indeed this aspect of management appears to be changing, albeit slowly and painfully, in many of the former strongholds of Taylorist methods. Several examples of managerial "conversion" have emerged in the US and British motor car industries in the 1980s. Although Taylorist attitudes to employee development commonly prove tenacious, the threat of corporate extinction has in many of these cases ultimately proved a powerful spur to change.

Thus organisational structure has a major influence on new technology. And the effect is not one-sided. The nature of new technology (high productivity potential plus range and complexity of scope within organisations), together with the increasingly rapid punishment of laggards by the international market-place, is expected to undermine managerial policies unfavourable to the development of employee skills and initiative.

D. INFORMATION TECHNOLOGY AND INDUSTRIAL RELATIONS

Some of the most acute concerns about the prospects for IT have been voiced in the context of industrial relations. On the one hand, some express the fear that workers and trade unions will resist technical change, whether because of threats to job security and

75

occupational status or out of simple attachment to customary practices. On the other, trade unions perceive a threat from new technology, fearing that the wider bundle of changes in which it arrives will require them to run faster simply to stay in the same place. The latter set of issues, the influence of new technology upon industrial relations, is considered first, followed by an assessment of the constraints imposed by industrial relations upon the implementation of new technology.

Both issues need to be seen in the context of changes that have come about due to persistently high unemployment within OECD economies. The bargaining aspirations of trade unions have been reduced relative to those of employers; simple job security has moved up the list of objectives. Unions have lost power, and have been put on the defensive over membership and recognition. At the same time, increased competition in product markets has forced management to pay greater attention to all aspects of organisational activity, not least to personnel procedures and employee relations.

1. The effects upon industrial relations

As IT has extended to an increasing range of workplaces during the 1980s, trade unions have been forced to rethink established attitudes and recast previous policies. The adverse effects of unemployment upon membership rolls can only be increased, should trade unions remain passive, by the IT-related shift towards smaller plants, part-time work and female employment (in each of which union membership density has always been low); towards an increased emphasis on service (as opposed to materials-transforming) work; and towards increased managerial use of "high trust" approaches to employee relations, including the strategy of excluding trade unions by providing benefits as good as could be expected to be won by unions. Although trade union response has taken some time to emerge, a refocusing of effort has recently become visible. Recruitment drives have been launched in the direction of high-tech labour forces, including those of firms which seek to remain non-union. Part-time workers have been targeted as well, with offers of benefit packages tailored to their particular requirements. Unions have also competed in their enthusiasm for new technology and their willingness to assist management implement new organisational forms.

Such changes are particularly striking in a British example, the electricians' union (EETPU), whose strategy involves: the promotion of single-union deals (a relative novelty in the United Kingdom); the targeting of foreign employers about to set up new plants, seeking recognition from them rather than from their employees; and the provision of IT-related training to its own members. EETPU's approach has been met with widespread criticism within the Trades Union Congress. Nevertheless, it has prodded the union's closest rivals [notably the traditionalist Amalgamated Engineering Union (AEU)] to make similar moves, while indirectly pressuring other trade unions to come up with alternative strategies of their own. Interunion competition is particularly marked in the United Kingdom, but parallels can be seen in the economies of some other countries, notably Italy.

While the bargaining difficulties of trade unions in the 1980s stem from other sources as well, new technology renews a particular source of union weakness: national frontiers. Corporate employers in both industry and the services operate to an increasing extent on a global scale. Indeed, new technology has permitted the continuing internationalisation of corporate activity. Yet trade unionism remains largely bounded by the national frontier. International co-ordination of union activities has emerged in recent years, particularly in bargaining with specific corporations. To the extent that corporations can switch production to other countries during industrial disputes without fear of an effective response, the union bargaining position is weakened. The advantages of new technology do not, however, accrue entirely to the corporate side. The "just in time" production methods and intra-corporate product specialisation that commonly accompany IT leave corporate activities taking place in several countries vulnerable to disputes in any one country.

On the side of inter-employer organisation, the implications of new technology are mixed. Smaller plant sizes may to some extent result in smaller firm sizes. The difficulties experienced by some large corporations in their attempts to seed innovative high-tech activities point in this direction. If so, the services of employers' associations, which have in some countries declined in the face of increasing firm size and more active corporate personnel policy, may be set for a revival. Since employers' associations can use IT to improve the speed and range of services provided to member firms, their ability to maintain their role in industrial relations may be bolstered in countries such as the United Kingdom and the United States, where it had previously declined. Some employers' associations have already taken the initiative. In 1981 the central Danish employers' organisation (DA) set up a special section to deal with technological change, productivity and organisational development.

2. Industrial relations and the utilisation of IT

The key questions concerning the effects of industrial relations on the adoption of new technology may be divided into two categories: those relating to *a)* procedure and *b)* substantive outcomes. To what extent is the implementation of IT procedurally subject to notification, discussion and negotiation? What have been the substantive outcomes of negotiation over new technology, including the degree of constraint upon the implementation of IT?

a) *Procedure: involvement and negotiation*

The degree to which employers involve their employees in the process of planning for and the installation of new technology is highly variable, depending on the country and the organisation. In Scandinavia, management is generally required by law to notify employees of major technical change and to bargain with unions over its implementation. Similar conditions prevail under co-determination in Germany. In the United Kingdom and the United States, however, the situation is different: employee involvement is a matter for management discretion, subject to the ability of unions to negotiate a role for themselves.

The consensus of industrial relations experts, employer organisations and trade unions favours the early involvement of employees in determining the course of technical change. Two difficulties present themselves in relation to early notification and involvement: *i)* what exactly is meant by "early" and *ii)* which elements of the change and its effects are appropriate for discussion and negotiation?

For trade unions, "early" is likely to mean at the time when management is still considering the various options. Even then unions may feel they are at a disadvantage, since the manning of new equipment is often part of that equipment's design. An interesting example concerned the manning of an aircraft. The manufacturer had designed the flight-deck on the basis of two-person operation. The unions argued that three people were needed – but by that time the aircraft were already built. From the management point of view, the timing of notification and involvement is not straightforward. Most decisions emerge through intra-management meetings and consultations in such a way that it is often difficult to decide at which point a proposal is reaching final approval. To inform workers of proposals that are in a formative stage may be counter-productive, and to discuss such proposals

77

confusing. On the other hand, of course, if involvement is deferred until management is sure as to what it wants to do, workers will feel they are being brought in only when it is too late to take account of their views.

The gap between actual and best practice is as wide in the area of employee notification and involvement as it is in other areas of innovation management. Some employers go out of their way to involve employees in the process of change even when not constrained by law or collective agreement. Examples from the United States include IBM, Ford and General Electric. However, many others still prefer to introduce new technology without prior information or discussion, seeking principally to avoid delays and restrictions. Daniel sums up managerial policy in the United Kingdom as "minimally pragmatic...if they could introduce the changes they wanted without having to take account of the views of any other group or individual, they did so" [Daniel (1987, p. 13)]. This approach is reflected in a tendency for the introduction to be left to line managers, with personnel specialists having at most an ancillary role.

Although gains may be made in the speed of implementation by excluding employee participation, the potential losses in terms of both ideas and commitment are marked. Some chance for discussion remains even after installation, but both management and workers stand to gain by employee involvement at an early stage.

The reluctance of many employers is commonly countered by collective agreements and statutory arrangements which typically require employee involvement in and negotiation over major technical changes [European Trade Union Institute (1979), (1982), (1985); International Labour Organisation (1985)]. Examples of negotiated procedures include: a 1983 Belgian national agreement which requires at least one month's written notification of major changes and discussion of their content; a 1987 French metalwork industry agreement which requires prior notification to, discussion with and presentation of an adjustment plan to enterprise-level committees in cases of major innovation; a 1975 Norwegian central agreement which accorded to workers rights of participation and training, as well as access to documents and information; and a 1980 agreement between Bell Telephone and the Communications Workers of America (CWA) which stipulated at least six months' advance notice of major technical change, as well as the establishment of a Joint Technology Committee to institutionalise employee involvement. The British union leadership launched a drive for New Technology Agreements at local level [Trades Union Congress (1979)]. Although only a limited number of agreements have been negotiated and despite its inclination to avoid a formal commitment to employee consultation where possible, British management has typically felt obliged to hold consultations informally with union representatives and employees, the former occurring in 69 per cent and the latter in 58 per cent of a sample of workplaces affected by new technology [Daniel (1987)].

The limits of collective bargaining as a means of securing employee involvement have prodded some governments towards legislation. The best-known cases are the establishment of general provisions in Norway, Sweden and Germany, including Norway's 1977 Work Environment Act, Sweden's 1976 Co-determination at Work Act, and German employers' long-standing obligation to secure the agreement of Works Councils for major changes. The legislative focus in France and Canada has been more explicitly directed at new technology [Hingel (1984)]. A 1972 Canadian federal law required employers to give 90 day's notice of change (increased to 120 days in 1982).

All the same, worker involvement in IT implementation may remain a formality unless two conditions are met. In the first place, representation should be at the appropriate level. The implementation of IT in British public utilities has suffered from an unsuitable participation mixture: extensive involvement of union officials at national level and weak involvement of employees and union officials at local level. Secondly, the workers and union officials involved must be knowledgeable, which requires training for the union duties with which they are entrusted.

b) *Worker resistance to new technology*?

When the introduction of new technology is subject to negotiation, a central issue concerns the acceptability of the change to employees and unions. The matter requires discussion in two areas – the extent of resistance to the change itself and the terms on which agreement can be reached. Section B, which dealt with managerial use of IT to intensify supervisory control, considered an informal and individual variant of resistance. Collective resistance to new technology is most likely to occur where trade unions are organised along specific occupational lines and where IT threatens to reduce the technical requirement for members' skills. There are many examples from the United Kingdom. The introduction of computerised typesetting in the national newspaper industry during the last decade has produced a series of conflicts between proprietors and the compositors' union (NGA), with the latter successfully retaining a role in spite of losing its *raison d'être*. Fleet Street is indeed an extreme case, by the standards of both the international newspaper industry [Griffin (1984)] and British industrial relations more generally. Nevertheless, other examples of difficulties in the United Kingdom can be found in industrial maintenance work, where the traditional division of mechanical and electrical functions between two separate unions (AEU and EETPU) has impeded moves toward multi-skilling in some plants; and in drafting, where several employers have faced industrial action as a result of attempts to implement CAD/CAM on a specialised, "dedicated" basis [UK Engineering Industry Training Board (1982); Arnold (1984)].

Such cases have been widely publicised and have contributed to the popular view that unions resist new technology. A closer look, however, establishes that even these disputes concern not the installation of new technology but rather the terms and conditions of its implementation. The Luddite option (outright opposition) is rarely considered. Moreover, these well-publicised cases are unrepresentative. The terms demanded by most unions constitute a relatively minor constraint upon managerial freedom of action – and may in some cases save management from the consequences of a misguided deskilling strategy.

Most importantly, even in the United Kingdom most unions and employees have proved actively supportive of new technology's introduction. Favourable overall employee and union attitudes have been reported for both the United Kingdom and Canada [Daniel (1987, Chapter 8); Economic Council of Canada (1987)]. The accounts of British managers suggest that more than four fifths of the employees affected, manual as well as nonmanual, favour advanced technical change. In cases where union officials were involved in negotiating innovation, a larger minority was described by managers as having proved "slightly resistant" than in the case of employees, but this may well reflect a tendency to avoid involving officials when there is no conflict. In any event, strong resistance proved very rare indeed; resistance was less marked among shop stewards, who typically negotiate for employees, than among full-time officials; and a clear majority of both types of employee representatives welcomed new technology to one degree or another (Table 3.4).

c) *Substantive bargaining outcomes*

Broad labour support for new technology does not, however, rule out concern over the details of its introduction. The most important immediate considerations from the workers'

Table 3.4.

Reactions of managers, workers and union officials to the implementation of new technology in the United Kingdom[a]

Percentages

Response	Manual occupations				Office occupations[b]			
	Full time managers	Workers	Shop stewards	Full time union officials	Full time managers	Workers	Shop stewards	Full time union officials
Strongly in favour	54	39	37	36	60	48	25	18
Slightly in favour	28	39	35	28	26	43	45	38
Slightly resistant	17	20	25	34	10	15	24	36
Strongly resistant	2	3	2	2	3	2	5	7

a) Managers' accounts, referring to persons affected only.

b) Word processing and computing only.

Source: Daniel (1987, Tables VIII.2, VIII.10).

standpoint have to do with prevention: no one should be dismissed or suffer a cut in wages; one's skills should not be downgraded; and new methods of working should be safe. But also, unless the enterprise is in a particularly difficult competitive position, workers will view new technology as an opportunity for improved earnings, reduced hours of work, enhanced skills, and better working conditions.

The productivity gains produced by radical innovation facilitate successful negotiation of terms and conditions, particularly in terms of pay. Conflict is, however, common over the criteria for pay increases, with employers favouring their limitation to cases of upgraded job content and opposing the principle of paying to secure acceptance of technical change *per se*. The issue is usually resolved somewhat less than dramatically. The employees affected tend to secure increases in pay moderately above the average, with regrading, bonuses and overall settlements all contributing to the outcome. Another area of conflict concerns the possibility of adjustments in the criteria underlying payment structures. Some German trade unions have pressed employers to relate individuals' pay to their level of skills rather than to the jobs which they perform at any particular time. Such a change would complement a skill-developing mode of IT implementation and has already been adopted by at least one large US manufacturing corporation. However, German employers have thus far refused to yield on the issue.

The prospects for job security appear more problematic, as sharp productivity gains may reduce labour requirements directly relating to the innovation. Concern for job security is particularly strong in Europe, where unemployment remains high. However, the threat to employee interests is blunted by the sheer variety of the buffers between technical potential and compulsory redundancy, including: less-than-optimal methods of implementation, which lower productivity gains; increases in the organisation's demand for the output of the function affected (e.g. larger information flows); reductions in overtime and subcontracting; and reductions in manning through ordinary turnover and voluntary departure.Even if all these buffers fail to cushion the shock of reduced manpower requirements, progressive personnel policy (*à la* IBM), collective agreement or public law (*à la* Germany) may impede enforced departures. Consequently, it is unusual for new technology to lead to compulsory redundancy. In the United Kingdom, compulsory job loss proves only marginally higher in workplaces affected by new technology than elsewhere [Daniel (1987, p. 236)]. Under these circumstances, managerial willingness to avoid direct job loss commonly suffices to win agreement on the introduction of IT.

The bargaining agenda also includes other concerns; prominent among these are working time, working conditions and job content. To take up the question of working time, the flexibility of operations that is both facilitated and (in cases of increased capital costs) required by IT tends to undermine the standard working week in favour of (for example) the working month or year. Simultaneously, the operational requirements of automated facilities have promoted shift-working in unaccustomed parts of manufacturing, notably small batch production.

These two effects in combination have created some bargaining difficulties, notably in Germany. The reduction of the working week has been the major focus of industrial conflict in German metalworking during the past decade; unions have sought to convert the productivity growth associated with new technology into shorter hours and more jobs on terms and at rates that employers have been unwilling to accept. The reductions in hours negotiated after two major disputes included a novel degree of flexibility; this came in the shape of framework agreements which specify the average working week but also permit local variation according to shift-work needs and the time of month and year.

Similarly, the introduction of new technology has been associated in recent years with an

81

increased utilisation of part-time workers, especially in the service sector and in retailing and clerical jobs. The contribution of IT to such developments is limited but clear: employees are ordinarily freed from traditional time-attendance requirements. Persons with domestic responsibilities may use IT to work at home. In other cases, IT's tendency to simplify work tasks reduces training costs, further encouraging the use of part-time workers.

In the area of working conditions, new technology has proved a mixed blessing. On the one hand, electronic automation has continued the displacement (begun after mechanisation) of heavy, dirty, boringly repetitive tasks in favour of work that is light, clean and interesting (exemplified by the ultra-modern semiconductor factory). On the other hand, there are matters of concern, including the possibly adverse health effects of extensive work at video display units (VDUs) – particularly for pregnant women – and any inclination by management to use IT to reduce worker skills and autonomy. British white-collar unions such as TASS and APEX have negotiated agreements which prohibit management from using IT to monitor employee performance or to specialise job tasks [Manwaring (1981)]. One third of a sample of new technology agreements in the United Kingdom referred to machine monitoring, mostly in order to curb it but also in some cases to meet management's desire to establish a monitoring role for IT. A similar proportion involved clauses on job tasks and content [Williams and Moseley (1982)]. The effectiveness of such restrictions remains dubious.

d) *Job content and organisational change*

Thus workers and unions generally welcome technical change, and issues such as pay, job security and working conditions have generally proved readily negotiable. However, it would be incorrect to conclude that the industrial relations system imposes no serious constraints upon innovation. While welcoming even radical technical change, workers and unions prove less receptive to organisational change – a category which includes the redesign of jobs, job ladders and authority relationships. Given that the full benefits of new technology are typically realised only when organisations are systematically reshaped as well, industrial relations cannot be regarded as a secondary implementation factor.

Concern on this score is particularly marked in the United States and the United Kingdom, albeit for different reasons. The US collective bargaining system appears favourable to innovation, in that management traditionally reserved the right to introduce new techniques during the contract period and often proved reluctant to negotiate technological issues during contract renewal. However, post-war US collective bargaining fostered plant-level "internal labour markets" that were characterised by a high degree of inflexibility in job content, labour allocation and pay structure. The work rules which governed these matters served to protect the pay and job security of senior workers from the competition of other workers, both inside and outside the plant, as well as to ensure a stable system of skill-learning and worker motivation [Piore (1982*a*, 1982*b*)].

During the past decade, however, American management has chafed increasingly under the restrictions embodied in these work rules. The success of foreign competitors has fostered a sense that more flexible working arrangements are needed, both to raise productivity in general and to implement new technology in particular. Consequently the relaxation of negotiated work rules became a major managerial objective in the wave of concession ("give back") bargaining in the first half of the 1980s. Union resistance initially proved more intense on work rules than on pay cuts; usually, changes were agreed to only under the threat of plant relocation [Strauss (1984); Kochan *et al.* (1984)].

Nevertheless, it seems that US management has increasingly realised the desired organisational changes. To some extent this reflects a "retreat from collective bargaining" itself, as well as managerial persistence and union adaptation [Edwards and Podgursky (1986)]. Several large companies have negotiated wholesale reductions in the number of job categories. Unions have moved towards seeking job security in skills rather than in seniority, bargaining for training benefits. In one dramatic example of change, the Fremont assembly plant was reopened by a GM-Toyota joint venture only on condition that working practices were radically revised: workers had to agree to a high degree of job flexibility and the removal of the seniority consideration in job allocations, while management was required to listen to all worker suggestions concerning process and product.

More systematic information is available on a similar phenomenon in the United Kingdom. Although organisational rigidities are along different lines and are less commonly formalised than in the United States, the strength of British resistance to organisational change has long been recognised. A 1984 workplace survey shows a much higher incidence of worker and union opposition to changes in work organisation (including working practices) than to technical change. According to managerial accounts, more than half of the manual workers and shop stewards affected by organisational change showed at least some resistance to IT, as opposed to roughly one quarter in the case of IT unaccompanied by organisational change; for nonmanuals, the gap between responses to the two types of change was even greater (Table 3.5). While their own reactions in this area were not reported, managers may also have been more opposed to organisational change than to technical change.

The unpopularity of organisational in comparison with technical change among workers cannot be explained in terms of job security or earnings, but rather reflects intrinsic interest in new equipment combined with a "low trust" suspicion of managerial intentions in reorganising work. Unfortunately, the British study did not examine the interaction between technical and organisational change. An optimistic inference would be that general resistance to organisational change may be weakened when it is accompanied by the new technology. The pessimistic corollaries are that *i)* management has an incentive to duck the crucial issue of organisational redesign around new technology altogether, given the greater difficulty of winning support for organisational change; and *ii)* unless the more difficult issue of organisational change is handled with care by management, the level of support for new technology will be weakened.

Pulling together the various ways in which new technology is related to industrial relations, the key issues again concern management policy and practice. To implement new technology successfully, careful attention to personnel and industrial relations issues is an essential complement to the broader rethinking required for technical and organisational change. The managerial cultures that prove least effective in the latter respect are also likely to fall down in the former. Organisational change will be promoted by the exigencies of corporate competition, but it has already proven painfully slow in many enterprises.

E. CONCLUSIONS

The relationship between new technology and work organisation is characterised by great diversity as well as mutual dependence. New technology promises to revolutionise the way work is organised in many institutions – and has at times already done so. The direction and extent of change, however, is difficult to predict in particular cases as it depends on a range of factors – among which managerial strategy stands out as the most important. In practice,

83

Table 3.5.

Reactions of British workers and shop stewards to different forms of change, according to managers[a]

Percentages

Response	Manual				Non-manual			
	Workers affected		Shop stewards		Office workers affected		Shop stewards	
	Advanced technical change	Organisational change	Advanced technical change	Organisational change	Computers or word processors	Organisational change	Computer or word processors	Organisational change
Strongly in favour	36	10	37	15	38	20	25	4
Slightly in favour	36	31	35	26	40	26	45	33
Slightly resistant	18	36	25	39	14	32	24	40
Strongly resistant	2	17	2	21	2	9	5	24
Not stated	8	6	0	0	8	13	0	0

a) **Base**: establishments with 25 or more manual workers reporting major change.

Source: Daniel (1987, Tables IV.1, IV.11).

skill-using modes of implementation prove more common than skill-reducing ones, although there is reason for concern over loss of worker autonomy and initiative. At the aggregate level, where microprocessor-based innovation continues the upgrading of demands made on the skills of the labour force in a wide range of areas, skill enhancement is expected to prove the rule (outside the personal service sector, at least).

At the same time, the speed, extent and success of innovation depend heavily upon the organisational context, particularly the qualifications, attitudes and structure of management. The demands made upon organisations and individuals by large-scale IT applications are extensive. Ad hoc and partial responses are particularly likely when management lacks an adequate background in systems and product engineering, when departmentalism is marked, when the intricate links between technical and organisational change are not appreciated and when Taylorist orientations prevail. The outstanding results already attained by some enterprises, most notably in Japan, Sweden, Germany, the United States and Finland, reflect a combination of attributes that competitors in other countries will need to adopt if they are to survive, let alone flourish.

The role of industrial relations in the innovation process has proved potentially important; problems occur only when systems of work regulation are inflexible or managers inattentive to the complexities of negotiating organisational change. Organised resistance to innovation itself is relatively rare. Although demands for notification, involvement and even negotiation of the terms of IT's introduction remain a source of difficulty, they have been muted by unemployment and increased recognition of the role of innovation in promoting job security. To some extent a convergence of employer and union interests can be detected in the area of implementation strategy. Where skill-enhancing modes are selected, employee co-operation is particularly likely – and is indeed part of the reason why such modes are often more productive than Taylorist ones.

BIBLIOGRAPHY

ADLER, P. (1983), "Does Automation Raise Skill Requirements? What, Again?" Paper presented to the Conference on Microelectronics in Transition: Industrial Transformation and Social Change, University of California, Santa Cruz, May.

ARNOLD, E. (1983), "Information Technology as a Technological Fix: Computer-Aided Design in the United Kingdom", in Winch (1983).

ARNOLD, E. (1984), "The Draughtsman's Contract", *CADCAM International*, February, pp. 20-21.

BALL, G.F. (1979), *Report on vocational education and training for employment in engineering in Japan*, Engineering Industry Training Board, Watford (mimeo).

BARRAS, R. and SWANN, J. (1983), *The Adoption and Impact of Information Technology in the UK Insurance Industry*, Technical Change Centre, London.

BAUMOL, W.J., BLACKMAN, S. and WOLFF, E.N. (1985), "Unbalanced Growth Revisited: Asymptotic Stagnancy and New Evidence", *American Economic Review*, Vol. 75, September, pp. 806-817.

BESSANT, J. (1983), "Management and Manufacturing Innovation: The Case of Information Technology", in Winch (1983).

BESSANT, J.R., BOWEN, J.A.E., DICKSON, K.E. and MARSH, J. (1981), *The Impact of Microelectronics: A Review of the Literature*, London: Frances Pinter.

BLUMBERG, M. and GERWIN, D. (1981), *Coping with Advanced Manufacturing Technology*, IIM Discussion Paper 81-12, Berlin.

BRÖDNER, P. (1987), (ed.) Options for New Production Systems: CHIM- Computer and Human Integrated Manufacturing, FOP No. 150, Brussels.

BRUSCO, S. and SABEL, C. (1981), "Artisan Production and Economic Growth", in B. Wilkinson (ed.), *Dynamics of Labour Market Segmentation*, London: Academic Press.

BUCHANAN, D. and BODDY, D. (1982), "Advanced Technology and the Quality of Working Life: The Effects of Word Processing on Video Typists", *Journal of Occupational Psychology*, Vol. 55; pp. 1-11.

BURNS, A., FEICKERT, D., NEWBY, M. and WINTERTON, J. (1983), "The Miners and New Technology", *Industrial Relations Journal*, Vol. 14, No. 4, Winter, pp. 7-20.

CHILD, J., LOVERIDGE, R., HARVEY, J. and SPENCER, A. (1984), "Microelectronics and the Quality of Employment in Services", in Marstrand (1984).

COMMISSION OF THE EUROPEAN COMMUNITIES (1982), *The FAST Programme*, Vol. 1: "Results and Recommendations", Brussels.

CROMPTON, R. and REID, S. (1982), "The Deskilling of Clerical Work", in Wood (1982).

DANIEL, W.W. (1987), *Workplace Industrial Relations and Technical Change*, London: Frances Pinter.

DICKSON, K. (1980), "Petfoods by Computer: A Case Study of Automation", in Forrester (1980).

d'IRIBARNE, A. (1982), "Vocational Education and Training and the New Technologies: The Key Role of the Enterprise", OECD, Paris (mimeo).

ECONOMIC COUNCIL OF CANADA (1987), *Making Technology Work*, Department of Supply and Services, Government of Canada, Ottawa.

EDWARDS, R.C. and PODGURSKY, M. (1986), "The unravelling Accord: American Unions in Crisis", in R.C. Edwards, P. Garonna and F. Totdling (eds.), *Unions in Crisis and Beyond*, Dover, Massachusetts: Auburn House.

ELIASSON, G. (1981), "Electronics, Economic Growth and Employment – Revolution or Evolution?", in H. Giersch (ed.), *Emerging Technologies: Consequences for Economic Growth, Structural Change and Employment*, Tubingen: Mohr.

ELIASSON, G. and RYAN, P. (1987), *The Human Factor in Technological and Economic Change*, OECD, Paris.

EUROPEAN TRADE UNION INSTITUTE (ETUI) (1979), *The Impact of Micro-electronics on Employment in Western Europe in the 1980s*, Brussels: ETUI.

EUROPEAN TRADE UNION INSTITUTE (ETUI) (1982), *Negotiating Technological Change*, Brussels: ETUI.

EUROPEAN TRADE UNION INSTITUTE (ETUI) (1985), *Technology and Collective Bargaining*, Brussels: ETUI.

FLECK, J. (1983), "Robotics in Manufacturing Organisations", in Winch (1983).

FORD, B. (1986), "The Transfer of Culturally Specific Technologies to Australia", in B. Ford and L. Tilley (eds.), *Diversity, Change and Tradition: The Environment for Industrial Democracy in Australia*, Canberra. Australian Government Publishing Service.

FORRESTER, T. (1980), (ed.) *The Microelectronics Revolution*, Oxford: Basil Blackwell.

FOX, A. (1974), *Beyond Contract: Work, Power and Trust Relations*, London: Faber.

FROHMAN, A. (1982), "Technology as a Competitive Weapon", *Harvard Business Review*, Vol. 60, January, pp. 97-104.

GERWIN, D. (1982) "Do's and Dont's of Computerised Manufacturing", *Harvard Business Review*, Vol. 60, March, pp. 107-116.

GOLD, B. (1982), "CAM Sets New Rules for Production", *Harvard Business Review*, Vol. 60, November, pp. 88-94.

GRIFFIN, A. (1984), "Technological Change and Craft Control in the Newspaper Industry: An International Comparison", *Cambridge Journal of Economics*, Vol. 8, No. 1, March, pp. 41-62.

GUILIANO, V.E. (1982), "The Mechanization of Office Work", *Scientific American*, Vol. 247, No. 3, September, pp. 125-134.

HAYES, C., ANDERSON, A. and FONDA, N. (1984), *Competence and Competition*, Report to National Economic Development Office (NEDO) and MSC, Brighton: Institute of Manpower Studies.

HINGEL, A. (1984), "A Promethean Change of Industrial Relations: A Comparative Study of Western European Unions and Technological Developments", in Warner (1984).

INTERNATIONAL LABOUR ORGANISATION (ILO) (1985), *Technological Change: The Tripartite Response, 1982-85*, Geneva: ILO.

KOCHAN, T., MCKERSIE, R.B. and CAPELLI, P. (1984), "Strategic Choice and Industrial Relations Theory", *Industrial Relations*, Vol. 23, No. 1, Winter, pp. 16.

LONG, R.J. (1984), "Microelectronics and Quality of Working Life in the Office: A Canadian Perspective", in Warner (1984).

LUTZ (1981), "Education and Employment: Contrasting Evidence From France and the Federal Republic of Germany", *European Journal of Education*, Vol. 16, No. 1, pp. 73-86.

MANWARING, T. (1981), "The Trade Union Response to New Technology", *Industrial Relations Journal*, Vol. 12, No. 4, July, pp. 7-26.

MARSTRAND, P. (1984), *New Technology and the Future of Work and Skills*, Frances Pinter, London.

MAURICE, M., SELLIER, F. and SILVESTRE, J.-J. (1984), "The Search for a Societal Effect in the Production of Company Hierarchy: A Comparison of France and Germany", in Osterman (1984).

OECD/CERI (1986), "New Technology and Human Resource Development in the Automobile Industry", Paris.

OECD/CERI (1988), *Human Resources and Corporate Strategy: Technological Change in Banks and Insurance Companies*, Paris.

OKAMOTO, H. (1983), "New Technology, Workshop Organisation, Education and Training", OECD, Paris (mimeo).

OSTERMAN, P. (1984), *Internal Labour Markets*, Boston: MIT Press.

PIORE, M. (1982*a*), "American Labour and the Industrial Crisis", *Challenge*, Vol. 25, No. 1, March, pp. 5-11.

PIORE, M. (1982*b*), "Fissure and Discontinuity in US Labour Management Relations". Paper presented to the Annual Conference of the International Working Group on Labour Market Segmentation, Aix-en-Provence.

RADA, J. (1986), "The Role of Management Development in Technological Change". Paper presented to seventh annual EFMD Corporate Members' Meeting, IBM, A.K. Watson IEC, La Hulpe, March.

RAY, G.F. (1984), *The Diffusion of Mature Technologies*, Cambridge, England: Cambridge University Press.

ROTHWELL, S. (1984), "Company Employment Policies and New Technology in Manufacturing and Service Sectors", in Warner (1984).

RYAN, P. (1987), *The Prospects for Higher Education in the Information Age*, Working Paper, Information Society Studies Series, Toronto: Institute for Research on Public Policy.

SENKER, P. (1984), (ed.) "Learning to Use Microelectronics: A Review of Empirical Research on the Implications of Microelectronics for Work Organisation, Skills and Industrial Relations", Science Policy Research Unit, University of Sussex, Brighton, England.

SHIMADA, H. and MacDUFFIE, J.P. (1987), *Industrial Relations and "Human ware": Japanese Investments in Automobile Manufacturing in the United States*, Cambridge, Mass.: Center for Technology Policy and Industrial Development, MIT.

SORGE, A. and WARNER, M. (1980), "Manpower Training, Manufacturing Organisation and Workplace Relations in Britain and West Germany", *British Journal of Industrial Relations*, Vol. 18, No. 3, November, pp. 318-333.

SORGE, A., HARTMANN, G., WARNER, M. and NICHOLAS, I. (1983), *Microelectronics and Manpower in Manufacturing*, Aldershot: Gower.

STRAUSS, A. (1984), "Industrial Relations: A Time of Change", *Industrial Relations*, Vol. 23, No. 1, Winter, pp. 1-15.

TRADES UNION CONGRESS (TUC) (1979), *Employment and Technology*, London: TUC.

UK ENGINEERING INDUSTRY TRAINING BOARD (EITB), (1981), *Maintenance Skills in the Engineering Industry: The Influence of Technological Change*, Occasional Paper No. 8. Watford: EITB.

UK ENGINEERING INDUSTRY TRAINING BOARD (EITB), (1982), *Designing the Future – the Implications of CAD Interactive Graphics for Employment and Skills in the British Engineering Industry*, Occasional Paper No. 9, Watford: EITB.

US DEPARTMENT OF LABOR (1977), *Technical Change and Manpower Trends in Six Industries*, Bulletin 1817.

US DEPARTMENT OF LABOR, BUREAU OF LABOR STATISTICS (1979*a*), *Technical Change and Its Labor Impact in Five Energy Industries*, Bulletin 2005.

US DEPARTMENT OF LABOR, BUREAU OF LABOR STATISTICS (1979*b*), *Impact of Technology on Labor in Five Industries*, Bulletin 2033.

US DEPARTMENT OF LABOR, BUREAU OF LABOR STATISTICS (1982), *Impact of Technology on Labor in Five Industries*, Bulletin 2137.

WARNER, M. (1984), *Microprocessors, Manpower and Society: A Comparative, Cross-national Approach*, Aldershot: Gower.

WILKINSON, B. (1983), *The Shopfloor Politics of New Technology*, London: Heinemann.

WILLIAMS, R. and MOSELEY, R. (1982), "The Trade Union Response to Information Technology", Paper presented to EEC/FAST Conference on the Transition to an Information Society, London.

WINCH, G. (1983), (ed.) *Information Technology in Manufacturing Processes*, London: Rossendale.

WINCH, G. (1983*a*), "Organisation Design for CAD/CAM" in Winch (1983), *op.cit.*

WOLFF, E. and BAUMOL, W.J. (1986), "Growth of the Information Sector in the Postwar US Economy", Institute for Research on Public Policy, Toronto (mimeo).

WOOD, S. (1982), *The Degradation of Work?* London: Hutchinson.

ZUBOFF, S. (1982), "New Worlds of Computer-Mediated Work", *Harvard Business Review*, Vol. 60, No. 5, September-October, pp. 142-152.

Chapter 4

HUMAN RESOURCE DEVELOPMENT

A. INTRODUCTION

As advanced economies become more knowledge-intensive, human resources become more central to economic progress. According to Drucker (1983), "knowledge work" has become the economy's growth area in the mass conversion to new technology; this means that productivity will increasingly be determined by the knowledge and skills workers put into their tasks. Another observer notes that human knowledge has replaced machines and plant as the moving factor behind productivity change, and that when the requisite knowledge is missing, output suffers – however much finance and hardware are supplied [Eliasson (1987)]. Such changes reflect rapid alteration in the content of work as a result of new technology and managerial policy. Chapter 3 has argued that in many contexts productivity is impaired by Taylorist forms of work organisation, while successful enterprises have usually been characterised by innovative, learning-based techno-cultures. Flexible production systems emphasize technical understanding and teamwork, which require more qualified staff at all levels.

The requisite human resource development involves investment principally in education and training, with secondary contributions from health and labour mobility. This chapter focuses on the first two areas, employing the term "skill" to denote all relevant learning under the rubrics of education and training.

The importance of the "human capital" component of national wealth has been widely recognised in recent decades. It has grown rapidly in advanced economies, not only in absolute terms but also relative to physical capital. Kendrick (1976) estimated that the stock of intangible human wealth (comprising the education, training and health care embodied in the labour force) grew from 48 per cent of the stock of physical capital in 1929 to 75 per cent in 1969. Education and training accounted for the bulk (89 per cent) of the stock of human wealth in the latter year.

Although the relative importance of human resources has clearly been higher in the United States, with its massive rates of participation in higher education, it has undoubtedly risen in advanced economies generally during the past two decades. Outlays for vocational training are less readily gauged in view of the difficulty of costing on-the-job training and the lack of comprehensive data on national spending on human resource development. However, according to a recent estimate, US corporate expenditure on employee training rivals that nation's outlay on higher education: between $30 billion and $50 billion annually, employing approximately 700 000 full- and part-time instructors [Dunn (1983)]. A rapid growth in training expenditures is suggested, given that the annual rate of investment in the United States *circa* 1960 was estimated at only $3 billion to $4 billion [Ryan (1977, Chapter 3)].

The current decade has seen growing policy interest in human resource development. Governments have become increasingly concerned that national systems of education and training may be inadequately adapted both to meet the need of increased international competition in general, and of new technology in particular. Specifically, there is concern over the volume and quality of learning, both in schools and in workplaces. Skill shortages have also attracted concern in several economies. Finally, there are recurrent worries over inequities in access to skill-learning, particularly in the cases of women, displaced adults and disadvantaged youth. All of these concerns may be intensified by new technology.

Adult learning stands out as a potential problem area. The state of "permanent revolution" that IT introduces to products and processes requires a recurrent remoulding and upgrading of knowledge and skills during the life cycle if the individual is to stay abreast of current basic job requirements. Unless education and training systems provide this skill "renovation", adults will lose out – and then the economy will lose out as well, from the premature discarding of the skills and experience of the adult population affected. As Perelman (1984) concludes, the "post-industrial" economy demands a new kind of learning enterprise, focused on adults rather than children, on learning rather than education, on technology rather than institutions, and on private competition rather than public administration. He notes that the adult learning crisis – which has been obscured by the recent uproar over children's education – is what will really put the US economy at risk between now and the beginning of the next century.

In this chapter we discuss the response of education and training systems to the demands of new technology, distinguishing between the amount of learning provided (Section B) and the content of that learning (Section C). Issues of access and equity are taken up in Section D, followed in Section E by the conclusions.

B. SKILL DEVELOPMENT: QUANTITY

The responsiveness of Member countries' systems of human resource development is inevitably constrained, in the short term at least, by the extremely rapid diffusion of IT. For example, although the number of electronics engineers at work in the United Kingdom had doubled during the previous two years, employers still wished in 1983 to employ half as many again [Northcott and Rogers (1984)]. Similarly, even the renowned Japanese skill development system has been unable to keep up with the demand for software engineers, leading to intense corporate rivalry for the available supply. In such cases, even rapid increases in supply have proved incapable of meeting the rise in demand.

Education and training systems often have structural defects that produce skill shortages, even when the pace of expansion is less hectic. Organisations and economies that have not yet developed mechanisms to assure supplies of suitably qualified manpower suffer skill deficiencies. Particularly lacking is the provision of education and training for costly transferable skills (i.e. those that require extended and expensive education and training and that are readily utilised by a wide range of employers). There are fewer problems of supply with less costly and employer-specific skills.

A distinction should be made between skills developed primarily in schools and those developed at the workplace – a distinction admittedly far from sharp, as advanced skills are typically developed through both classwork and job-based training and experience. Nevertheless, the extent to which either method is employed will vary depending on the occupation, with the share of classwork high for professional skills and the share of job training high for manual skills. Inadequate provision can lead to skill shortages in each case, but the sources of the problem and the appropriate remedies differ. Electronics engineers and maintenance craftworkers provide examples illustrative of differing structural problems of skill provision in the context of IT implementation.

1. School-based skills

A particular set of difficulties is illustrated by the example of electronics engineers, the supply of which has significant gestation period. In the late 1970s the shortage of high-level engineering skills was found to be "the greatest single impediment" to the development of micro-electronics [Science Council of Canada (1980)]. The United Kingdom and Japan continue to have shortage problems in the 1980s. Dynamic elements clearly matter, given the three- to four-year period that it takes to complete the appropriate courses of higher education and given the limited scope for increasing supply by upgrading the skills of engineers in related fields.

Structural factors are also important. Potential increases in the salaries of electronics engineers – which would encourage a greater response of supply to excess demand – are often nipped in the bud by rigidities within pay structures. Notwithstanding the recognised role of

Table 4.1.

Public expenditure on post-secondary education as a percentage of GDP: OECD economies, 1970-82

Three-year averages

Country	Education expenditure on					
	Current account			Capital account		
	1970/72[a]	1975/77	1980/82	1970/72	1975/77	1980/82
Austria	0.51	0.67	0.71	0.18	0.18	0.11
Canada	2.03	1.97	1.88	0.44	0.20	0.18
Denmark	1.18	1.20	1.04	0.38	0.16	0.06
Finland	0.53	0.71	0.94	0.11	0.14	0.11
France	0.54	0.62	0.60	0.11	0.05	0.02
Germany	0.41	0.67	0.62	0.21	0.16	0.08
Ireland	0.62	0.94	0.99	0.16	0.15	0.22
Italy	0.44	0.50	0.44	0.05	0.06	0.07
Japan	0.30	0.42	0.42	0.13	0.10	0.12
Netherlands	1.64	2.00	1.90	0.31	0.18	0.20
New Zealand	0.98	1.00	1.08	0.29	0.26	0.15
Norway	0.75	0.80	0.78	0.18	0.18	0.09
Sweden	0.86	0.79	0.69	..	–	..
Switzerland	0.59	0.73	0.86	..	–	..
United Kingdom	1.17	1.16	1.16	0.22	0.13	0.10
United States	1.53	1.66	1.60	0.33	0.21	0.16
Total 1[b]	0.68	0.75	0.72	0.16	0.11	0.10
Total 2[c]	1.10	1.15	1.09	0.24	0.16	0.12

a) Average of values for three years (or for number of years data are available).

b) Shares of dollar equivalent aggregates (calculated at mid-year spot exchange rates); Denmark, the Netherlands, Sweden, Switzerland and the United States are excluded from aggregates.

c) Total 1 plus the United States.

Source: Ryan (1984, Table 4).

small firms as employers in this field, the bulk of employment continues to be provided by large, established organisations whose other employees are typically reluctant to see the pay of any one occupation increase in response to market shortages without expecting comparable increases themselves [Mace (1979)]. In the United Kingdom the difficulty is compounded by the low base salaries and corporate status of engineers, which results in both low interest in engineering degrees and high occupational turnover among the qualified [Finniston (1980)].

A further structural problem results from the dominant role played by the public sector in both the finance and provision of higher education, particularly in Europe. Public willingness to pay for education, especially beyond the compulsory level, has declined in most economies since 1970. This has led to the drop in higher education's share of governmental budgets. Public spending on post-secondary education in a group of sixteen OECD economies declined from 1.34 per cent to 1.21 per cent of GDP between the mid-1970s and the early 1980s (Table 4.1). Further reductions have since been imposed in some countries, notably the Netherlands and the United Kingdom. Moreover, as spending generally declined much more rapidly on capital than on current account while enrolments continued to grow in most countries (Table 4.2), capital inputs per student have fallen sharply – an ominous development, considering the re-equipment needs precipitated by new technology.

Table 4.2.

Changes in real capital outlays and enrolments in public post-secondary education: OECD economies, 1970-82

Percentages

Country	Change (1970/2-1980/2) in	
	Real gross capital expenditure[a]	Enrolments[b]
Austria	–12.7	112.4
Canada	–39.0	42.7
Denmark	..	24.8
Finland	39.0	103.2
France	–73.3	34.7
Germany	–50.9	124.8
Ireland	114.1	95.2
Italy	73.4	36.4
Japan	42.6	25.9
Netherlands	–35.0	51.6
New Zealand	–40.1	20.6
Norway	–26.7	50.0
Sweden	..	50.5
Switzerland	–24.1	63.4
United Kingdom	–43.6	39.4
United States	–36.2	38.4
Total 1[c]	–20.0	43.4
Total 2[d]	–29.3	39.8

a) Deflated by GDP deflator.
b) Full-time and part-time enrolments.
c) Denmark, the Netherlands, New Zealand, Sweden and the United States are excluded from aggregates as a result of gaps in data.
d) Total 1 plus the United States.
Source: Ryan (1984, Table 8).

Gains in efficiency within educational institutions have undoubtedly cushioned the effects of these cuts. However, the cutbacks in spending have far surpassed the scope for efficiency savings – a tendency fostered by the belief that such efficiency gains can be translated indefinitely into a higher rate of productivity growth within education. In a sector so prone to the "cost disease of the services", this belief is as mistaken as it is widespread among policy-makers [Eliasson and Ryan (1987, Chapter VI)].

The implications of low or declining public willingness to pay for higher education depend upon the availability of alternative sources of finance. In this respect, Japan and the United States are better placed than are the European economies, given that private provision and finance play a much greater role in their higher education systems [Geiger (1986)]. The Japanese situation proves particularly favourable, given the greater availability of public funding for higher education and the widespread use of private provision and finance. The United Kingdom again suffers by comparison. Although the scale of public cuts has not been exceptional, the lesser role of private provision has limited the expansion of enrolments, while the severity of cuts on capital account has impaired the speed and scope of the implementation of new technology.

2. Workplace-based skills

Similar problems can arise for different reasons in the area of skilled manual work, where new technology intensifies the trend towards functional flexibility and multi-skilling. The skills of maintenance craftworkers and CNC operator-technicians resemble those of electronics engineers in that they require a theoretical foundation best developed in the classroom. But they differ in requiring a greater blend of practical experience, i.e. workplace-based training. This is clearest in the apprenticeship programmes of the German-speaking economies; however, even in countries that rely primarily on public vocational education (such as Sweden, France and Belgium), training at the workplace remains essential to the development of such skills.

This brings up the question of employer willingness to provide and finance the requisite training. Substantial costs are involved; often more than one advanced skill has to be learned – mechanical, electrical and electronic for maintenance work, metalwork and programming for CNC operation. Moreover, the skills produced by such training tend to be highly transferable between employers, raising the prospect that the firm's investment may be poached. Although standard economic theory predicts that the trainee and not the firm will pay for the general training, in practice pay structures require employers themselves to finance most or all of any training that they provide. Thus British metalwork employers invest an estimated $9 000 in the training of each manual craft apprentice [Jones (1986)]. Employer investments in apprentice training in Germany have also been substantial, even though trainee incomes are low by British standards [Edding (1974); Noll *et al.* (1983)].

The cost of training discourages employers from providing it and encourages the recruiting of the already trained. Consequently, the training that is offered by many employers proves inadequate to meet their own skill requirements, while some offer do no training at all. The difficulty is most marked among small firms that could benefit from new technology but are ill-equipped, both physically and financially, to undertake the necessary education and training programmes. These structural deficiencies have been intensified in this decade by slack labour markets. Although widespread unemployment lessens the immediacy of the threat that low training levels will produce skill shortages, low employer profitability in the early 1980s precipitated extensive cuts in training activities in order to reduce losses on profit-and-loss statements [Sellin (1983)].

Employer willingness to train is also eroded by the trend, especially among larger companies, to externalise a growing range of functions requiring special expertise, particularly in order to evade the obligations of long-term employment contracts. The recent proliferation of smaller enterprises, especially in the service sector, reflects the growing diversification and destabilization of employment patterns [Christopherson (1987)]. The growth of fixed-term contracts, part-time work and labour subcontracting tends to intensify employer reluctance to train. In view of the limitations of employer provision, only post-compulsory education may be able to provide access to skills for the growing army of "contingent workers".

In this structural context, the widespread association of new technology with higher skill levels and multiple areas of qualification means an increase in the costs of training and the prospect of reduced employer willingness to provide and finance such training. The resulting skill shortages in turn discourage skill-using applications of new technology, raising the possibility of a Taylorist vicious circle of low skills and low training – even when management otherwise lacks Taylorist inclinations.

The problem may be reduced if governments or individuals finance training. Public provision and finance of vocational education along Swedish or French lines certainly reduce the importance of employer willingness – as does financing by individuals, who pay for a significant share of the costs of junior college courses in the United States. Lower trainee pay encourages higher levels of workplace training in many countries, but there are questions about trainee exploitation and institutional feasibility [Garonna and Ryan (1986)]. In any case, both the ability and the willingness of many individuals to finance costly and risky skill development are inevitably limited. The provision problem is therefore most pressing in economies such as the Italian and the British, where both public provision of and individual willingness to pay for vocational training are limited.

There is evidence that structural skill shortages have in some economies hampered the introduction of new technology. Such shortages may show up in quantitative or qualitative form. The former is common in the United Kingdom. A study of robot installations attributed both slow rates of diffusion and high rates of failure mainly to shortages of suitable maintenance skills, on top of inadequate technical training in general. These shortages reflected the greatest single problem reported by users of robots, namely the difficulty of retaining suitably trained maintenance men – especially in firms without technical personnel due to a lack of any other automation [Fleck (1983)]. Nearly one half of a sample of 36 new technology projects in process industries reported that the lack of relevant skills had proven a "major barrier" to innovation. A similar proportion of manufacturing plants using IT indicated that the lack of employees with electronic expertise had proved a "very important" impediment to utilisation [Cross (1983); Northcott and Rogers (1984)]. Widespread employer unwillingness to provide training in metalwork maintenance skills was explained in another study in terms of fears that multi-skilled employees would attract other companies, particularly equipment service firms. The fear of skill loss was also linked to the option of self-employment – and even provoked by raiding on the part of other departments within the same company [Senker *et al.* (1981); Incomes Data Services (1984)].

These deficiencies in the supply of craft and technician skills in the United Kingdom find a parallel in the United States, where the lack of a national structure of qualifications transfers the problem from job vacancies to the quality of skilled workers. The informality of vocational training in the United States is reflected in the 1983 finding that only two fifths (39 per cent) of all employees had received formal education and training of qualificatory relevance to their present jobs – and less than one quarter (23 per cent) had received training for skill improvement while holding those jobs. The majority received either no training or informal training only [US Department of Labor (1985)]. The informality of training impairs the performance of many enterprises [Ryan (1984)].

The skill shortage situation is, however, far from universal, even in those economies most prone. Large employers possessing both considerable power in product and labour markets and progressive views often provide a high volume of training despite the disincentives outlined above. The priority attached to human resource development by such corporations as Matsushita, IBM, Siemens and Polaroid is long-standing. Japanese automobile plants in the United States spend more than $40 000 on the initial training of each team leader, with new technology a part of the task.

Even corporations not previously noted for their interest in employee development, such as General Motors and Lucas (a major British manufacturer of automotive components), have in the 1980s radically changed course and increased their training activities. Most symbolic of the change in corporate attitudes is that of the creator of "fordism" itself. Ford has recently set aside $34 million to establish education/training centres at all 22 of its United Kingdom plants. Employees are to be encouraged to study work-related courses in these centres on company time as long as production is not impaired [Incomes Data Services (1984)].

The limitations of single-employer provision are sometimes offset by inter-firm co-operation. The four leading employers of graduate-level software specialists in the United Kingdom agreed early in 1988 on an industry-wide scheme for the organisation of workplace training, involving the inspection and certification of particular programmes. Joint programmes involving large and small enterprises, especially subcontractors, have been developed in Sweden, while Germany possesses an array of inter-enterprise training centres established at local and sectoral levels through chambers of industry and commerce.

At the national level, employer willingness to train is particularly high among large firms in Japan, where it is encouraged institutionally by lifetime employment practices and demonstrated by extensive upgrading of production workers to technician and indeed professional skills. Even in that country, however, the shortage of software engineers has led both employers and employees to violate the norm of company loyalty: competition over bonuses induced employees to quit in such numbers as to threaten the viability of the lifetime employment system itself; until the major employers agreed to limit their bonus payments to forestall the threat.

The German economy is also endowed with a generally abundant supply of skills, not least because of the extent and quality of the apprenticeship training provided by employers. This provision is encouraged by a culture of respect for skill; by institutional support from local chambers of commerce; and by the threat of public intervention in case of quantitative failure [Taylor (1981); Hayes *et al.* (1984)].

Corporate policies that favour employee development generally coincide with skill-enhancing applications of new technology. The reverse combination also exists. Managerial preference for unvarying work procedure in an Irish electronics plant led to curbs on technicians' interest in both enhanced access to technical learning and greater product quality, both of which management perceived as incompatible with the requirements of volume production [Murray and Wickham (1983)]. Skill shortages seem to be absent in such cases because jobs are designed to limit skill requirements, but in fact a qualitative problem remains.

This limited willingness on the part of the state, employers and individuals has clear policy implications. The conflict between fiscal restriction and educational provision, particularly at the post-compulsory level, needs to be recognised and alleviated. A variety of policy responses to employer reluctance are possible, including collective regulation of the content of workplace training and low trainee allowances, as in German apprenticeship; levy/grant redistribution systems, as attempted in the United Kingdom and France; "renewal funds" for education, as in Sweden; and, in the last resort, public subsidies to employer training for key skills. It is often preferable to spend public money to offset the failures of private provision than to permit the latter to damage the effective utilisation of new technology.

C. SKILL DEVELOPMENT: CONTENT AND QUALITY

The content of education and training has come under scrutiny in an age of rapid and widespread technological advances and intensified international competition in product markets. Shortcomings in national economic performance have been laid increasingly at the door of public education in particular.

This has led to conflict over the goals and methods of education. In countries where the liberal and academic values have dominated the content of education, the "new vocationalism" has insisted upon the inculcation of the three Rs, increased scientific and technical content and a greater emphasis on business values. Some have even called for the universal dissemination through education of a culture that is essentially technological. On the other hand, formal education does have to serve a range of social, cultural and political goals; it cannot respond only to economic and technological change. Moreover, the educational lobby is powerful enough to resist policies that ignore liberal values or its own interests. However, the opposing factions recognise that formal education remains a key policy medium for stimulating a long-term response to new technology.

Conflicts of view have been less major in the case of vocational training, where short-term perspectives have generally held sway. That agenda has been dominated by the content of initial training, where a muted version of the conflict over education can be seen in some countries: the long-term perspective and the educational interest call for a broad vocational foundation for all workers, while many employers prefer short and limited training focused upon particular job assignments.

This section considers in turn the various stages of education and training in the sequence characterising the life-cycle: from compulsory general education to post-compulsory and vocational education and job training.

1. Compulsory education

Utilisation of new technology in initial education has varied widely in degree. Some countries have focused on the need to install equipment in the school, relying on direct exposure to IT to foster student interest and learning. Other educational systems have extended this approach to the use of IT to direct education towards the vocational requirements of the technician and craft skills. Still others have gone further and attempted to recast much of the curriculum around IT, as in the French orientation towards generalised access to informatics [OECD/CERI (1986)]. These varied responses share a tendency towards the exposure of an increasing range of students to the use of computers for problem-solving, not just as a specialised subject in secondary school but as a general medium at all levels of education.

At the same time, the effective use of IT in schools is often more an aspiration than a reality. It is circumscribed in the first place by the complexity of implementation and the resulting demands upon the skill and time of teachers [OECD/CERI (1986)]. A further difficulty involves prevailing pedagogical practice and classroom relationships. In schools serving working class communities in the United States, for example, the use of computers has been heavily slanted towards drill and practice functions; the microcomputer teaches existing materials in a pedestrian manner. Only in the more student-centred schools in affluent communities have problem-solving and modelling proved primary activities [Useem and Kimball (1983)].

The reshaping of education in response to new technology has also been hindered by the deterioration of job rewards in the teaching profession, notably in the United States and the United Kingdom. The pay and working conditions of teachers have been hit by fiscal retrenchment at a time when the burgeoning information economy has required an increase in the quantity and quality of educational staff in relevant subjects. The low level of salaries (in the United States, teaching is the lowest paid of all the professions requiring a four-year degree) together with abundant, highly paid job vacancies in the private sector's technological sciences has made it difficult for schools to attract sufficient staff to meet pre-existing teaching loads, let alone the pedagogical demands of new technology. Selective pay increases, which might permit more effective competition for qualified personnel, are usually blocked by the institutional requirements of inter-subject equality in teaching pay structures. School systems operating under such constraints consequently limp along with a staff inadequate in numbers and qualifications for the teaching of technology and related disciplines (notably mathematics and physics).

The pace of technical change has become so rapid and much of the technology is so expensive that, particularly at a time of fiscal restriction, public educational facilities experience great difficulty in providing training of adequate relevance and quality. The problem of out-dated equipment and instruction – one already familiar to vocational education – is now magnified. Development of computer literacy is considerably complicated (and thus hampered) by the lack of widely acceptable standards for software languages and systems design. The variety and instability of both equipment and software raise the cost of achieving proficiency, thereby encouraging the same limitation of horizons impairing implementation of new technology at the workplace. International co-operation to increase standardization – as well as the easing of funding restraints – would help greatly in this area.

The school system must also deal with changes in requisite worker characteristics. New technology tends to reproduce in batch production the job content of the traditional process industries, i.e. the high levels of both technical understanding and vigilance (with regard to malfunctions). The normative and intellectual demands on employees are increased. Traits of reliability and responsibility cannot be formed from scratch in workplace training but must be developed earlier, particularly in school.

That is the minimum requirement of the school system seen as an agent of normative development. To the extent that employers respond to new technology positively by utilising skills, their task will be facilitated by schools instilling a "technological culture", stressing initiative, problem- solving and openness to change [d'Iribarne (1981)]. This places great demands on schools, particularly in view of their prior success in adapting to Taylorist work organisation in factories and offices with a regime that denied enthusiasm, autonomy and problem-solving to the majority of pupils [Gintis (1970)].

In a time of high unemployment and changing family roles, a further challenge for the school system has been to prepare young people for a higher level of change and uncertainty in career patterns and a greater availability of disposable time. Clearly, schools need to respond to this challenge; less clear, however, is the form that that response should take.

Finally, policy has sought to weaken the boundary between school and workplace teaching. The failings of strictly school-based vocational education on the one hand and of learning at the workplace on the other have produced in the 1980s an extension and modification of the late sixties movement for alternance training and education. Work experience has been featured increasingly in secondary schools in Sweden and the United Kingdom. Some large Swedish corporations, including Volvo and SKF, have sponsored industrial high schools whose curricula contain a high technical and vocational content. In the United Kingdom, continued access to education after leaving school has been realised to some extent in the off-the-job component of the Youth Training Scheme. The work experience contracts developed for unemployed young people in France and Italy since 1978 also attempt to combine workplace and school instruction.

Industrial sponsorship of schools has also been geared to the recasting of curricula, the updating of equipment and the alleviation of funding difficulties. The famous Boston Compact involves employers providing equipment and job guarantees to local schools on condition that pupils meet attendance targets. The Boston model is currently being utilised with government encouragement in the United Kingdom.

2. Post-compulsory education

Pressures for content changes in post-compulsory education have also been intense, particularly in countries where generalist ideals had previously dominated, such as the United Kingdom. British public policy declared recently that higher education must take "increasing account of the economic requirements of the country", manifesting "greater commercial and industrial relevance" and a "positive attitude to enterprise" [UK Department of Education and Science (1985, pp. 1-2)]. As these demands come at a time of continued reduction in real funding levels, government has sought to respond by slanting the distribution of student places towards the sciences in general and the technological sciences in particular [UK Department of Education and Science (1987)]. However, the problems arising from reduced per capita funding have been intensified by this shift in emphasis, given that resource costs per student are nearly twice as high in these subjects as in the arts and social sciences [UK Department of Education and Science (1985)]. The result has been scores of complaints from colleges and universities about obsolete equipment and defective facilities [UK University Grants Commission (1984)]. Furthermore, the decline in the relative pay of academics has led to difficulties of staff retention and quality analogous to those in the compulsory education system – again, particularly in the sciences. The cuts have therefore taken their inevitable toll on the new technology content of education in the United Kingdom.

That the need to enhance the technological content of post-compulsory education in Germany and Japan is less urgent reflects the higher public esteem for education and the traditionally strong place held by technical subjects in curricula in those countries. Indeed, it is the lack of a technological culture on a Japanese or German scale that hampers government efforts to increase the output of engineers in the United Kingdom. Student demand has not increased as rapidly as the supply of places in engineering, reflecting the enduring preference for the arts and social sciences – which in turn reflects enduring employer preferences for nonspecific degree subjects. In Japan, however, there is considerable concern about educational content in relation to the creativity of Japanese society in general and the aversion to rote learning and vigorous self-expression in particular.

The necessity for adaptation in educational institutions goes beyond the immediate need for more engineers and technologists or for wider dissemination of business values. There is also the issue of management education. As IT places particularly intense demands upon management in terms of numeracy, abstract thought and breadth of vision across subjects and departments, appropriate managerial education has become a vital matter. US business schools pioneered this field of formal education; it is also taken seriously, with a stronger engineering foundation, in Japan and Germany. Some large US corporations, including GE and ITT, have set up their own business schools offering short courses to large numbers of managers on company time.

In contrast, a substantial proportion of British managers have never had higher education in any field, and of the remainder, many have received education only in the humanities. Add to this the extensive and durable functional specialisation that characterises management experience in the United Kingdom and France, and it becomes clear that managerial development remains a weak point in the response of post-compulsory education to new technology in some countries.

One area in which higher education has increased its responsiveness to the scientific and technical needs of modern economies is research activity, which has become more closely linked to the needs of employers. British universities are now encouraged to seek private funding for research; some of the more technologically oriented could not have survived the fiscal cuts of the early 1980s without succeeding in this area. An embodiment of this healthy relationship is the science park, which fosters a two-way flow: the utilisation of university research results in commercial ventures and the corporate provision of research equipment to universities.

The content of higher education has proved a major disappointment in that it is usually slow to adapt to changes in the technical and normative characteristics of professional and managerial work, which again underlines the importance of enterprise-based education and training. Also, the degree to which new technology has affected techniques of instruction and learning has been limited. While use has indeed been made of teaching machines (computers, sound-tape and videotape recorders) and distance learning (via telecommunications), such techniques have yet to affect higher education for 18- to 21-year-olds, which remains dominated by small-scale lecturing and all the consequent duplication of academic effort. A study of trends in the productivity of seventeen communications media in the United States during 1960-1977 found that the "education" sector (i.e. classroom instruction) was alone in showing a striking increase in costs per unit of output, while nearly all the others showed a moderate to dramatic decline [de Sola Pool (1983)]. Yet, many argue that it is technologically feasible to increase the productivity of education through the introduction of new technology [US Office of Technology Assessment (1982)]. According to Perelman (1984), the traditional school – a central edifice, compartmentalised into regimented rooms of desks, where lecture/recitation is the principal medium of instruction – should have as little place in 21st century education as the blacksmith has in today's transportation industry. Such an outcome cannot, however, be achieved without major institutional changes.

3. Vocational education and training

The changes in skill profiles resulting from the introduction of new technology research were discussed in Chapter 3. In the manufacturing sector, requirements are shifting towards multi-skilled roles, teamwork, and conceptual skills. In the service sector the focus is much the same, but with additional emphasis on customer and communication skills (Table 4.3). The

100

Table 4.3.

The changing nature of skills in banks and insurance companies

	Old competencies	New competencies
	General	
1.	Ability to operate in well-defined and stable environment.	Ability to operate in ill-defined and ever-changing environment.
2.	Capacity to deal with repetitive, straightforward and concrete work process.	Capacity to deal with non-routine abstract work process.
3.	Ability to operate in a supervised work environment.	Ability to handle decisions and responsibilities.
4.	Isolated work.	Group work; interactive work.
5.	Ability to operate within narrow geographical and time horizons.	Comprehensive grasp of systems; ability to operate within expanding geographical and time horizons.
	Specific *Among upper-tier workers*	
1.	*Generalist.* Broad, largely unspecialised knowledge; focus on operating managerial skills.	*New expertise.* Growing need for high-level specialised knowledge in well-defined areas.
2.	*Administrative.* Old leadership skills; routine administration; hierarchical, carrot-and-stick personnel management approach; ability to carry out orders from senior management.	*New entrepreneurship.* Capacity to not only manage but set strategic goals; to share information with subordinates and to listen to them; to motivate individuals to develop new business opportunities.
	Among middle-tier workers	
1.	*Procedural.* Specialised skills focused on applying established clerical procedural techniques involving the capacity to receive and execute orders.	*Customer assistance and sales.* Broader and less specialised skills focused on assisting customers and selling capacity; to define and solve problems.
	Among lower-tier workers	
1.	*Specialised skills* focused on data entry and data processing.	Disappearance of low-skill jobs.

Source: OECD/CERI (1988).

implications for the content of education and training are generally straightforward, but three aspects deserve attention.

The shift in manufacturing towards continuous process production has already been noted. The difficulty of developing the appropriate training programmes is reflected in the delays involved in incorporating new technological aspects into the existing activities certified for apprentice training in Germany [Krais (1979)]. This difficulty stemmed both from uncertainty about the technical knowledge required and from the need to break new ground in developing formal training in responsibility and reliability – hitherto the domain of traditional education and the family. At the same time, new technology has actually reduced an obstacle to training for process work: the cost of errors induced by inexperienced employees. Computerised training simulators can mimic actual work situations such as those of airline pilots and nuclear power station operators with sufficient accuracy for realistic mistakes to be made without the student wreaking actual havoc.

New technology also promises to tilt the balance in the conflict over the breadth of vocational training. In some countries, employers have insisted upon limiting training to the needs of particular jobs as they see them, resisting the interests of trainees in and the demands of educationists for broader, more theoretical background. There have been changes, however. Accumulating evidence of the benefits going to their leading competitors because of the broad knowledge and skills within their workforces is slowly but surely undermining the opposition of many "backwoods" employers.

Finally, the alteration in occupational profiles from pyramid to diamond shapes has already fostered the growth of vocational education for the burgeoning middle-rank technician occupations. In the United States, junior and community (i.e. two-year) colleges have effectively displaced high schools as the centre of gravity in vocational education [Grubb (1984)]. The proliferating CAP (certificat d'aptitudes profesionnelles) and BEP (brevet d'études professionnelles) certificates in secondary vocational education in France have catered to the same occupational needs [Steedman (1988)]. In the United Kingdom, the ratio of technician to craft apprenticeships in metalwork rose from 29 per cent to 52 per cent between 1967 and 1986 [UK Engineering Industry Training Board (1987)].

D. ACCESS TO SKILL

The scarcity of opportunities to learn skills poses problems of unequal access. The criteria used by educational institutions and employers to ration access are not usually considered inequitable in themselves. For example, the dominant role played by academic achievement in the allocation of places in higher education is broadly congruent with prevailing meritocratic values. However, inequities arise when such criteria indirectly impede access for particular individuals and groups through no fault of their own. It is difficult for adults to satisfy tests of academic attainment geared to the recent graduates of secondary schools, but this does not in itself mean that they are therefore less able, motivated or deserving than the average 18-year-old.

The difficulties already experienced by three groups in particular have attracted attention: unqualified young people; adults, particularly redundant middle-aged workers; and women.

1. Unqualified young workers

The difficulties faced by this group concern access to employment and vocational skill. Competition stemming from rising youth unemployment, combined with the large-scale elimination of less skilled jobs in manufacturing, has closed many doors to industrial employment [Roberts *et al.* (1987)]. Employers filling jobs offering training and career prospects can take their pick in slack labour markets. If their interest in young workers in general is limited, their interest in unqualified young workers is minimal. The deterioration in youth prospects has been most marked for non-white male teenagers in the United States, whose educational attainments remain below average and whose employment rate fell by half

102

between 1954 and 1977 Freeman and Medoff (1982)]; the situation can only worsen given the increased technical and intellectual demands associated with new technology.

Public policy has not remained inactive in this problem area. Youth has been the primary target of labour market intervention in several countries. In the United Kingdom, special public provision has been maintained under the Youth Training Scheme (YTS) for the most disadvantaged school-leavers, whom employers are least willing to select for training. Special emphasis has been laid on training in Information Technology Centres, which have provided many disadvantaged teenagers with an exposure to new technology difficult to secure otherwise.

Some have taken the argument further and called for provision of a foundation training for all young workers, partly in view of the requirements of new technology. YTS guarantees a place to all unemployed school-leavers. Similarly, European Community leaders adopted a declaration in 1982 favouring a guaranteed two-year course of continuing training for all young people [Sellin (1983)]. However, such policies cannot be justified simply in terms of economic efficiency; whatever the implications of new technology in industry, it is clear that the service sector will continue to require large amounts of less skilled labour. Equity – in the form of a second chance for disadvantaged young people – does, however, provide a justification for universal initial training. Although disadvantaged youth may still not gain access to the best training opportunities through such interventions, without them they may not gain access to any.

2. Adults

To some extent the problem concerns adults who have never gone beyond compulsory schooling – indeed many, particularly immigrants, have not even managed that – and who have undertaken no formal training, but who would like a second chance to do so. Also involved, however, is the more highly educated and trained adult who requires anything from a "refresher" to an entirely new programme of courses as a result of the elimination or upgrading of his or her job tasks by new technology. In both cases, access to learning opportunities may be difficult or even impossible.

The urgency of continuing education for adults is underlined by the presence of between 17 million and 21 million functional illiterates in the United States. The meagre skills of such people are inadequate for the demands of many ordinary workplaces, not to mention those of new technology. To rely on compulsory education to resolve this problem is both to assume no further immigration and to wait until the current generation has retired, i.e. well into the next century.

Continuing education has been a prominent policy issue in advanced economies for at least two decades. Educational leave was made a social right for all workers in France in 1973 [OECD/CERI (1976*a*)]. Similar provisions have been adopted in Sweden, Italy and Belgium, and the International Labour Organisation advocated that these be universalised in 1973 [OECD/CERI (1976*b*)]. Employer reimbursement of expenses for employee education is now widespread among large US corporations.

It is true that achievements have been limited. Adults experience difficulty both in satisfying the entrance requirements of educational institutions and in finding the finance and employer support for significant periods of study. Exercise of rights to educational leave by French workers has proven very low indeed, reflecting the losses of income and employer favour that usually ensues [Jallade (1982)].

Nevertheless, there are signs of change. In most countries, demographic trends involve a shrinking population of 17- to 21-year-olds, making adult demand the only growth sector in higher education. As a consequence, many educational institutions, particularly in the United States, are changing both the content and method of delivery in order to attract adult students. In some cases, information technology is used to provide this growing adult market with a flexible "time- and space-free" education [OECD/CERI (1987)]. Institutional adjustment is less rapid in Europe, however. Competition for enrolments is weaker when public provision and finance dominate, leaving the adult constituency relatively disadvantaged.

Even more important is the fact that an increasing number of large employers actively encourage their employees to continue their education – not so much through formal leaves of absence as through part-time study and recurrent short courses while still on the payroll. The German educational system is noted for the facility with which adults can switch tracks and even move up from apprenticeship qualification to technician and professional qualifications. However, access to such opportunities remains uneven; employees of small firms prove most likely to lose out [Centre d'Etudes et de Recherches sur les Qualifications (1987)].

Workplace training is open to criticism on grounds of equity, given that the scarce training slots provided by firms tend to be slanted heavily towards employees who are already well trained and qualified in addition to having the desired attitudes. Employers favour such workers in order to reduce both the cost of training and the danger of losing their investment as a result of turnover. New technology has intensified these practices, with the upgrade training provided to the current experienced workforce. Young, junior, less skilled and women employees are generally excluded, but so too are redundant adult men. Tendencies towards polarisation between a highly skilled, functionally flexible and secure "core" and an untrained and insecure "periphery" within corporate workforces have caused concern [UK National Economic Development Office (1986)].

As most public training programmes concentrate on the young, the disadvantaged and the long-term unemployed, displaced adults tend to be left out in the cold here, too. The skewed distribution of training resources – private towards the top of the job pyramid and public towards the very bottom – in fact leaves a significant number of workers in the middle with the least access to training and thereby particularly vulnerable to technological and economic changes. The redundant middle-aged male, however, provides the most vivid example.

In some instances collective bargaining has affected employer preferences and led to a wider distribution of training opportunities within the enterprise. Employer-financed retraining in the United States automobile industry demonstrates the results attainable by negotiation [Nollen (1984)]. Corporations such as GE have come to recognise the importance of their displaced employees' access to education and training and have planned plant closures in order to provide that access. However, where collective bargaining or employer provision fail to cater for displaced adults, the public establishment of rights of access to retraining, as adopted in Sweden, may be needed for an effective response to their problems.

3. Women

Although one of the stereotypes of new technology is the female clerical worker using office information systems, there is actually concern about women's access to such skills in terms of both formal education and job training.

The inadequate representation of women in formal education leading to the first degree level has in most advanced economies become a thing of the past. However, the rising share of women in post-compulsory education as a whole has yet to produce significant female shares in the disciplines associated with new technology – computing, mathematics, physics and technology – in contrast with the feminisation of the medical sciences. In 1983 more than 62 per cent of the successful candidates for the mathematics and physical sciences baccalaureate in France were male. Engineering and the applied sciences "remain male bastions" [OECD (1986)]. The only major exception is management education, where the proportion of women has risen strongly, particularly in the United States.

Low female participation in disciplines related to new technology stands to impair women's occupational prospects in an era of rapid technical change. The key job categories – professional and technical – whose growth is fostered by new technology are largely male preserves. In the field of management the low representation of women in engineering education will hold them back despite rising MBA achievements. The gender stereotyping that maintains occupational segregation is therefore very much in evidence in the realm of new technology.

A similar story must be told of workplace training. While it is customary to praise the vocational education and job training systems of Japan and Germany, reduced gender segregation *vis-à vis* opportunities cannot be claimed by either as an achievement. The training and retraining opportunities offered by large Japanese employers are largely denied to women [Mehaut (1985)]. The German system of near-universal apprenticeship practically involves single-gender training for occupations such as hairdresser, food salesperson and receptionist (for females) and electrician, machine fitter and motor mechanic (for males) [OECD (1986)]. Female employment prospects therefore depend heavily on personal services, while the growth of IT-related occupations is largely a matter for males. One factor clearly uniting the workplace training systems of advanced economies is the rigid division of work by gender and the concentration of new technology on the male side of the dividing line.

The story is similar for all learning situations up to and including adult retraining. The achievements of trade unions in negotiating access to retraining for displaced members have been noted. What is not generally noticed is that such achievements are typically limited *de facto* to males.

E. CONCLUSIONS

The demands of new technology upon systems of human resource development follow directly from their implications for work organisation. To the extent that new technology leads to an increase in skill requirements both within the workplace and within the economy as a whole, systems of education and training must increase their output. There is no doubt that such adaptation is possible. Successful examples can be found in the training programmes of many large corporations – some of them recent converts to belief in the importance of human resources – and in the higher education systems of many countries.

At the same time, adaptation is hindered by three constraints. In the public sector, the fiscal climate in most advanced economies remains one of rein-drawing. As education is for the most part a technologically stagnant sector, even constant funding means downward pressure on provision. At a time of increased demands placed on the education and training systems as a result of the IT revolution, the ability of publicly funded schools, colleges and universities to step up their output of suitably educated manpower without reductions in quality has been widely impaired.

The second constraint is the enduring prevalence of Taylorist attitudes within many enterprises, along with the structural disincentives to provide training in a labour market where employees with advanced skills may quit and join another employer. Access to up-to-date workplace training in IT is therefore denied to many workers who would value it – and even be willing to help pay for it. In some countries and in many small firms the result is quantitative or qualitative skill shortages, which in turn hamper the implementation of IT.

Finally, the evidence highlights the painful tension between the vital importance of human resources to successful innovation and the slowness with which organisations recognise that importance. In many cases, management and government continue to ignore the extensive experience of IT applications and organise work, education and training around new technology in ways that fail to enhance employee capabilities. Some already take a constructive view, and they are joined regularly by new converts. But until this particular light is seen by the great mass of employers, the gap between the productivity growth attainable with new technology and that actually attained will remain wide.

Education for an active society

Issues of equity are intensified by the advent of new technology in an era of high unemployment. Without public intervention, the least advantaged young people are in danger of being left behind by economic and technical progress. The result has been a variety of public interventions aimed at providing work experience, remedial education and exposure to new technology to these young people. Less impressive have been the responses aimed at displaced adult workers, whose ability to regain access to jobs with training content is particularly poor – except where public policy has been active or unions have been able to bargain for retraining funds. The premature disposal of the abilities and potential of such workers remains the least favourable human resource implication of new technology.

It is clear that education and learning will need to become a recurrent process; it is no longer possible for education to be limited to a certain period early in an individual's life, while the economy and society become increasingly knowledge-intensive. However, this simple principle is still far from being fully accepted, let alone implemented, in terms of opportunities and provisions.

The need for recurrent learning experiences is underscored by the changes in the economy and the workplace referred to in Chapters 1 to 3; an individual's future job security will increasingly depend on his/her access to educational opportunities throughout life. Such opportunities would also help develop individual initiative – one of the characteristics needed for social and economic well-being in a knowledge-intensive economy and an active society.

The concept of an "Active Society" was discussed in Chapter 2 in the context of full employment. The great achievements of the post-war period were essentially built on the idea that a full-employment economy, based on the active population, was productive enough to provide at least minimum income for the non-active population. Redistribution of income through taxes and social transfers was the vehicle, largely because the central political objective was to eliminate poverty of the few while the many got their income. However, the powerful demographic trend towards an ageing society in OECD countries, the new groups falling into the non-active population in complex, industrialised societies, and the threshold of tax resistance all put this linchpin of the system at some risk. In macro-economic terms, a shrinking active population coupled with a growing capital stock of increasing sophistication (robots, for example) may well generate sufficient income for the tax system to provide the non-active population with a reasonable material standard of living. But in social and political terms such a "dual" society, composed of "insiders" and "outsiders", is so incompatible with accepted standards in industrialised democracies that it is most unlikely to be a realistic long-term option. The Active Society is an alternative in which policies would be designed to help as many people as possible towards a positive role through which they can perceive themselves and be perceived as making a useful contribution to economic and social life.

Paid employment in the market has been this contribution's principal form, but new and varied forms are now developing. For many, the wider choices now available imply a major improvement in the quality of life, if also greater uncertainty. No doubt the diversity of careers open to many young people from diverse social backgrounds, the possibility of switching careers several times during a lifetime, and the prospect of more flexible patterns of education, work and retirement are a boon in societies needing flexible and dynamic populations.

And then there is the other side of the coin. This very diversity and volatility of opportunities implies a lack of structure for individuals; family, community and social background no longer provide the map for the future. Success in education and the access it gives to the labour market are one of the keys to opportunity, and failure – even relative failure – can be the first step in the downward spiral of unemployment, exclusion and poverty. The long-term unemployed, the handicapped, the single-parent heads of families and the drop-outs find that the longer they are out of the labour market, the more difficult it is for them to gain or regain a foothold. The emergence of such an "underclass" in modern society, now a reasonably well-documented phenomenon in some countries, probably cannot be resisted with Welfare State policies based on income maintenance alone, for these may foster the very dependence and alienation from which policy should help them escape.

What is called for is a shift towards preventative policies to keep vulnerable people actively integrated in society and to keep remedial services that sustain skills and motivation as foundations for returning to activity. There may even be a preference for subsidised activity rather than run the risk, both for the individual and for society, of long-term dependence.

How can this Active Society be realised? Advanced economies must carefully appraise the content, funding and provision of both education and job training in order to promote a continuing learning process – the key not only to successful utilisation of human resources and effective innovation in the economy, but also to job security, career prospects, meaningful activity and personal development for the individual.

BIBLIOGRAPHY

CENTRE d'ETUDES ET DE RECHERCHES SUR LES QUALIFICATIONS (1987), "Challenges to Education: Policies, Dilemmas and Social Inequities". Paper presented to the Conference on Microelectronics in Transition, University of California, Santa Cruz, May.

CHRISTOPHERSON, S. (1987), *The Origins of Contingent Labour Demand in Changing Production Organizations*, Washington: Women's Bureau, U.S. Department of Labor.

CROSS, M. (1983), *Changing Requirements for Craftsmen in the Process Industries*, Interim Report, London: Technical Change Centre.

DE SOLA POOL, I. (1983), "Tracking the Flow of Information", *Science*, 12th August.

d'IRIBARNE, A. (1981), "New Technologies and the Structure of Qualifications: An Approach Based on French Experience", Brussels: Commission of the European Communities.

DRUCKER, P. (1983), "Quality Education: The New Growth Era", *Wall Street Journal*, 19th July.

DUNN, S. (1983), "The Changing University", *The Futurist*, August, p. 72.

EDDING [Commission on the Cost and Financing of Vocational Training: SachverstandigenKommission Kosten und Finanzierung der Beruflichen Bildung] (1974), *The Cost and Finance of Non-School-Based Vocational Training*, Bielefeld: W. Bertelsmann Verlag K.G.

ELIASSON, G. (1987), "The Modern Industrial Firm", in Eliasson and Ryan (eds.) (1987).

ELIASSON, G. and RYAN, P. (1987)," *The Human Factor in Economic and Technological Change*", OECD/CERI Educational Monograph.

FINNISTON, M. (1980), "Engineering our Future", Report by the UK Committee of Inquiry into the Engineering Profession, London: Her Majesty's Stationery Office (HMSO).

FLECK, J. (1983), "Robotics in Manufacturing Organisations", in Winch (1983).

FORRESTER, T. (1980), (ed.) *The Microelectronics Revolution*, Oxford: Basil Blackwell.

FREEMAN, R.B. and MEDOFF, J. (1982), "The Youth Labour Market Problem in the US: An Overview", in R.B. Freeman and D.A. Wise, *The Youth Labour Market Problem*, Chicago: Chicago University Press.

GARONNA, P. and RYAN, P. (1986), "Youth Labour, Industrial Relations and Deregulation in Advanced Economies", *Economia e Lavoro*, Vol. 20, pp. 3-19.

GEIGER, R.L. (1986), *Private Sectors in Higher Education: Structure, Function and Change in Eight Countries*; Ann Arbor: University of Michigan.

GINTIS, H. (1970), "Education, Technology and the Characteristics of Worker Productivity", *American Economic Review*, Vol. 61, No. 2. pp. 266-279.

GRUBB, W.N. (1984), "The Bandwagon Once More: Vocational Preparation for High Tech Occupations", *Harvard Educational Review*, November, pp. 429-451.

HAYES, C., ANDERSON, A. and FONDA, N. (1984), *Competence and Competition*, Report to National Economic Development Office (NEDO) and Manpower Services Commission (MSC), Brighton: Institute of Manpower Studies.

INCOMES DATA SERVICES (1984), "Retraining", *IDS Study* 405, March.

JALLADE, J.-P. (1982), *Alternate Training for Young People: Guidelines for Action*, CEDEFOP, Berlin.

JONES, I.S. (1986), "Apprentice Training Costs in British Manufacturing Establishments: Some New Evidence", *British Journal of Industrial Relations*, November.

KENDRICK, J. (1976), *The Formation and Stocks of Total Capital*, New York: National Bureau of Economic Research.

KRAIS, B. (1979), *Relationship between Education and Employment and their Impact on Education and Labour Market Policies*, CEDEFOP, Berlin.

MACE, J. (1979), "Internal Labour Markets for Engineers in British Industry", *British Journal of Industrial Relations*, Vol. 17, No. 1, March, pp. 50-63.

MEHAUT, P. (1985), "The Development and Utilization of Human Resources In the Context of Technological Change in Industrial Restructuring: Public and Private Policies for the Development of Human Resources in France", OECD, Paris, (mimeo).

MURRAY, P. and WICKHAM, J. (1983), "Technical Training and Technical Knowledge in an Irish Electronics Factory", in Winch (1983).

NOLL, I., BEICHT, K., BÖLL, G., MALCHER, W. and WIEDERHOLD-FRITZ, S. (1983), "The Net Cost of Firm-Based Vocational Training in the Federal Republic of Germany", Berlin: CEDEFOP, (mimeo).

NOLLEN, S. (1984), "The Development and Utilisation of Human Resources in the Context of Technological Change and Industrial Restructuring: Country Study – United States", OECD, Paris (mimeo).

NORTHCOTT, J. and ROGERS, P. (1984), *Microelectronics in British Industry: The Pattern of Change*, London: Policy Studies Institute.

OECD (1986), *Girls and Women in Education*, Paris.

OECD/CERI (1976*a*) *Recurrent Education in France*, Paris.

OECD/CERI (1976*b*), *Developments in Educational Leave of Absence*, Paris.

OECD/CERI (1986), *New Information Technologies: A Challenge for Education*, Paris.

OECD/CERI (1987), *Adults in Higher Education*, OECD, Paris.

OECD/CERI (1988), *Human Resources and Corporate Strategy*, OECD, Paris.

OSTERMAN, P. (1984), *Internal Labour Markets*, Boston: MIT Press.

PERELMAN, L. (1984), *The Learning Enterprise: Adult Learning, Human Capital and Economic Development*, Washington D.C.: the Council of State Planning Agencies.

ROBERTS, K., DENCH, S. and RICHARDSON, D. (1987), "The Changing Structure of Youth Labour Markets". Research Paper No. 59, London: Department of Employment.

RYAN, P. (1977), *Job Training*, Harvard University, unpublished PhD. dissertation.

RYAN, P. (1984), "Job Training, Employment Practices and the Large Enterprise: The Case of Costly Transferable Skills", in Osterman (1984).

SCIENCE COUNCIL OF CANADA (1980), *The Impact of the Microelectronics Revolution on Work and Working*, Department of Supply and Services, Government of Canada, Ottawa.

SELLIN, B. (1983), "The Development of Alternance Training for Young People in the European Community", *Vocational Training*, Vol. 12, September, pp. 73-83.

SENKER, P., SWORDS-ISHERWOOD, N., BRADY, T. and HUGGETT, C. (1981), "Maintenance Skills in the Engineering Industry: The Influence of Technological Change", Occasional Paper No. 8, Watford: UK Engineering Industry Training Board.

STEEDMAN, H. (1988), *Vocational Training in France and Britain: Mechanical and Electrical Craftsmen*, Discussion Paper No 130, London: National Institute of Economic and Social Research.

TAYLOR, M.E. (1981), *Education and Work in the Federal Republic of Germany*, London: Anglo-German Foundation for the Study of Industrial Society.

TRADES UNION CONGRESS (TUC) (1979), *Employment and Technology*, London: TUC.

UK DEPARTMENT OF EDUCATION AND SCIENCE (1985), *The Development of Higher Education into the 1990s*, London: Her Majesty's Stationery Office (HMSO).

UK DEPARTMENT OF EDUCATION AND SCIENCE (1987), *Higher Education: Meeting the Challenge*, London: Her Majesty's Stationery Office (HMSO).

UK ENGINEERING INDUSTRY TRAINING BOARD (1987), Article in *Economic Monitor*, June.

UK NATIONAL ECONOMIC DEVELOPMENT OFFICE (NEDO) (1986), *Changing Working Patterns*, London: NEDO.

UK UNIVERSITY GRANTS COMMISSION (1984), *A Strategy for Higher Education into the 1990s*, London: Her Majesty's Stationery Office (HMSO).

USEEM, E. and KIMBALL, L.M. (1983), "High Technology and Challenges to Education: Policies, Dilemmas and Social Inequities", Paper presented to Conference on Microelectronics in Transition, University of California, Santa Cruz, May.

US DEPARTMENT OF LABOR (1985), *How Workers Get Their Training*, BLS Bulletin 2226, Washington, D.C.: Government Printing Office.

US OFFICE OF TECHNOLOGY ASSESSMENT (1982), *Information Technology and its Impact on American Education*, November, Washington, D.C.: OTA.

WARNER, M. (1987), *Microprocessors, Manpower and Society: A Comparative, Cross-national Approach*, Aldershot: Gower.

WINCH, G. (1983), *Information Technology in Manufacturing Processes*, London: Rossendale.

Chapter 5

NEW TECHNOLOGIES AND SOCIETY

The preceding chapters have stressed the endogenous nature of technical change. The new technologies are not a force originating from outside the economic system – they are created, developed and diffused in response to economic demands and constraints. Similarly, the impact of technical change is inseparable from other societal developments; its economic dimensions cannot be isolated from its social dimensions. What is involved is a set of interacting influences, in which history, culture, outlook and values carry just as much weight as economic forces. This chapter – more speculative in approach than those preceding – explores the nature of that interrelationship and some of its policy implications.

A. TECHNOLOGY AS A SOCIAL PROCESS

It is now apparent that technological change is closely associated with not only economic but also social, legal and cultural changes whose interaction is complex. Transformations in society and technology are at the same time cause and effect. The way in which societies adapt to these transformations is no more systematic than the technical system is static. In this sense, technology can be defined as a *social process* which by meeting real or imagined needs changes those needs just as it is changed by them. Society is shaped by technical change, and technical change is shaped by society. Technical innovation – sometimes impelled by scientific discovery, at other times induced by demand – stems from within the economic and social system and is not merely an adjustment to transformations brought about by causes outside that system [Salomon (1984); Salomon and Lebeau (1988)].

It is true that technology follows a logic of its own and its genealogy can be traced through the ideas of scientists, engineers and inventors. However, this does not mean that all the possibilities opened up by science and technology are necessarily exploited or developed. Industry in many sectors devises products that are ahead of their time and not put on sale. Such selection is not simply an economic process taking only cost criteria into consideration; it is also a social and cultural process in that the new product must be welcomed by members of the society concerned in their capacities as consumers, producers and citizens.

Technological trends do not follow a predetermined line any more than history does. As Fernand Braudel has pointed out, "Society in the broadest sense always has a say in a debate where technology is never the only voice" [Braudel (1979, p. 293)]. While the generation of new technologies may have become more scientific, this does not necessarily result in their diffusion following more direct paths. The pace is faster because the progress of technology

– and world wide trade – is such that new techniques can spread more rapidly and on a larger scale; yet the route followed is no straighter, nor is it without difficulties and detours, and resistance is often encountered along the way.

Viewed in the short term and on a micro scale, technical evolution may appear to be an autonomous process. This perception is widespread during periods when the environment (that is, social values and aspirations) is undergoing rapid change, such as the present [Brooks (1973)]. Technology, a long-term evolutionary process, appears to be out of tune with new values and expectations. However, if it is considered in a larger, longer-term context, it becomes clear that technology adapts to us – our working methods, way of life and thinking – no less than we adapt to it. Technology conditions the economy as it conditions history, but it is also the product and the expression of a culture. Technical mutations influence structures, mentalities and values; at the same time, however, the kind of transformation brought about by technology in a society will depend on the structures, mentalities and values of that society. In short, technical change has to be *mediated* if it is not to be rejected, since new technologies cannot take hold unless society is prepared to accept the changes they bring.

It is important to recognise that this cultural integration is bound to cause tensions and resistance. Ever since the Industrial Revolution began (and even before), the influence of technology on society has given rise to debate that has sharpened in recent years because of the scale, pace and pervasiveness of technology's diffusion and unevenness in the sharing of the benefits and costs. The conflicts created in societies and institutions – and in individuals, too – by the "creative destruction" process that characterises industrial "dynamics" do not necessarily signify unwillingness to accept innovation. They may reflect the will to defend legitimate interests, convictions and values. Any change brings upset and therefore concern; overly hasty introduction of certain innovations may give rise to all the more concern if these entail unexpected or uncontrolled consequences not only for working conditions but also for the environment, health, even life itself. Thalidomide, acid rain and DDT are examples demonstrating that the externalities of economic growth can carry a high cost. Consumer sovereignty must include the right to reject a new product or to insist on its modification.

B. THE SOCIAL INTEGRATION OF TECHNOLOGY

The best example of the complexity of this social interplay is probably telecommunications, where computers, television, telephone and new materials combine to multiply the audio-visual resources available for information, management, leisure, education, etc. The telecommunications business, one of the most healthy and active high-tech sectors, cuts across national markets. With deregulation, the old post office monopolies are giving way to new communications networks, resources and products (satellite and cable television, interactive videotex, teleconferencing, etc.) that affect not only business but everyday life as well – personal relationships, cultural activities and attitudes. Consumer reaction is transformed along with audio-visual techniques, and yesterday's "lonely crowd" of viewers, who supposedly watched television passively and attempted to emulate the social models they saw, may already be a thing of the past [Donnelly (1986)].

Montesquieu said that custom precedes law. Technical change precedes both custom and law. For instance, the rapid development of information technologies poses many new problems for the jurist. Only with difficulty can law that is based on the concept of ownership of tangible goods define and thus deal with the fraudulent use of, say, software or a magnetic card – intangible goods. Even more difficult questions, relating to ethics, are raised by the development of bio-technology. The example of the contraceptive pill shows the extent to which the diffusion of a technology can change behaviour and law (status of women, freedom to choose the moment of parenthood, family patterns and relationships, population growth, etc.). It also shows that no matter how important the new development may be, it always takes time to permeate through the social system; technical changes rarely translate into social transformations in the short term, particularly when they concern radical or generic innovations as defined in Chapter 1.

If the pace of technical change seems to be accelerating, this is not only because of the closer relations between science and technology (the laboratory and the factory) and the worldwide internationalisation of trade, but also because today any scientific or technical breakthrough is reported in the media almost at once and new products become obsolete much more rapidly. Yet it is by no means certain that the time-lag between a scientific discovery or technical innovation and its mass application is shorter now than it used to be.

The fact is that technical innovations cannot be widely applied without the requisite socio-institutional infrastructure. Their rate of diffusion depends on major social innovations, and people do not become familiar with the potential uses of a new product overnight. Moreover, the institutional complexity of some modern technological systems means that many technical and social innovations must be brought together to achieve productivity gains or other social goals. The success of the motor car depended not only on new, modern manufacturing methods but also on the establishment of a network of petrol stations and garages, new roads and motorways. Television required not only the installation of a network of transmitters and relay stations but also the creation of programmes, and here the financing methods used – combining resources from public and private institutions – were themselves a social innovation.

C. THE NEED FOR SOCIAL INNOVATION AND DEMOCRATIC VALUES

An earlier OECD report pointed out an apparent imbalance in the impact of technology [Brooks (1981)]. The costs or risks of a new technology frequently fall on a small proportion of the population, whereas the benefits are widely diffused – often so much so that the benefits to any given group are barely perceptible, even though the aggregate benefit to a large population amounts to considerably more than the total cost to the small group adversely affected. The calculation of the "greatest good of the greatest number" is a much more complex problem than Bentham and the early utilitarians supposed. Examples abound. Automation benefits the consumers of a product by lowering its price, but the costs in worker displacement are borne by a small number of people and may be traumatic. A large power-station may adversely affect the local environment, while providing widely diffused benefits to the population served by the electricity produced. Workers in unusually dangerous occupations such as mining carry a disproportionate share of the costs associated with resulting materials that may yield benefits throughout a national economy.

This disproportion between the distribution of costs and benefits can also work the other way. The effluents from a concentrated industrial area such as the Ruhr Valley or the American Great Lakes industrial complex may diffuse acid sulphates over a very large area that derives little benefit from the industrial activity while its quality of life as well as agricultural productivity badly suffers.

Public opinion is of course most sensitive to the cost-benefit redistribution that technological change brings about in labour markets, i.e. job losses, displacement and deskilling. Some skills are rendered obsolete, while others that are needed to master the new technologies become highly valued. The enterprises that are not keeping pace are threatened at the same time that new industries are appearing and regenerating manufacturing and services. On a larger scale, some regions are suffering from too heavy a dependence on traditional industries, while others are rapidly expanding their employment by attracting industries linked to the new technologies.

It is difficult to distinguish the new social, cultural and moral issues raised by the spread of the new technologies from the changes in attitudes, expectations and values that come about as society itself evolves. For instance, the arrival on the labour market of many more women may be attributed to changing attitudes, to economic developments (increased educational opportunities and expansion of the service sector), or to the spread of information technologies (new skill and job opportunities). Individuals, institutions and societies do adjust to technological change – and adapt innovations to their requirements, which are themselves subject to change – but there is more at work here than a simple cause-and-effect relationship.

That complexity extends to the problem of cost-benefit sharing and is the main reason why technical innovation must be accompanied by social innovation if it is to succeed. In confronting that problem it is extremely important to draw up "rules of the game" to ensure that adverse effects are less harmful than they would be if everything were left to the market – and to establish such rules early on, before vested interests, acquired privilege and the fierceness of competition jeopardise their application.

The structural changes that took place early on in the Industrial Revolution were not negotiated – and probably were not negotiable, since in most countries democracy was still in its infancy. The whole story of industrialisation may well be encapsulated by the tensions and conflicts over technical change and its consequences. Democracy in Europe has been won – and sometimes lost – in the context of such tensions, and its triumph can be measured in the negotiations, compromises and adaptations that have technical and social change.

In totalitarian societies there is little or no public discussion of controversial subjects such as the dangers inherent in certain types of research (e.g. bio-technology) or in large-scale projects (e.g. nuclear power-stations). It is precisely because OECD Member countries profess respect for the individual and for democratic values that there is public debate about controlling the consequences of technological change and about participation in relevant decision-making. The unease, tensions and protests that may result from a given technological development are aired in policy debate. This highlights the strength as well as the vulnerability of democratic societies, that is to say those where decisions on the legitimacy of technical changes are neither left to the specialists nor based solely on the demands of competition [Salomon (1981)].

D. SOCIAL RISKS AND COSTS

Scientific and technological progress has undeniably brought benefits to a great (and ever-increasing) number of people, at least in the industrialised societies. Fears that everyone would be the poorer for it proved groundless. Today, as a result of technical progress, per capita income in the industrialised nations is almost ten times higher than it was two hundred years ago. Certainly the unprecedented economic growth of the post-war years has fulfilled "the great hope of the 20th century" measured in terms of "the facts of production, consumption, length of working hours, health care and life expectancy" [Fourastié (1979 p. 245)]. Yet this purely quantitative indicator can give no idea how much the substantial rise in income has benefited the community and the individual: lower infant mortality, the disappearance of a number of diseases, a higher level of education, swifter communication, better living and working conditions, improved social welfare services, more opportunities in leisure pursuits, etc. Notwithstanding the inequalities and the poverty still to be found in the industrialised societies, materially the advantages of technical progress clearly outweigh its disadvantages. Whatever the problems raised by technical change, it is clear that there is little chance of coming to grips with many societal and economic problems if the resources offered by science and technology are not employed.

Nevertheless, certain costs and risks of technological change need to be taken into account. Two factors may be noted in the application of new technologies which can either separately or together, pose new problems: the complexity of systems and haste in the transfer from an experimental to a market phase.

Contemporary technologies are extremely complex in two respects: they depend on scientific knowledge and instruments, and they assume an organisational fabric which is itself complex to operate. Systems come into play here – networks of socio-technical relations involving factors of supply, maintenance, safety, insurance, etc., without which use of the technological products would be impossible. If the socio-technical system is a complex one, the social organisation is that much more vulnerable to accident or damage caused by the obstruction of just one part of the system. At the same time, the knowledge needed to understand the technical operation of the system has in some cases become so specialised as to be esoteric to the majority of people. Even specialist technicians in increasingly narrow fields have been cut off from one another by their respective skills.

The scale and complexity of the scientific technological enterprise mean that the potential consequences of accidents are unprecedented. In general, the science-intensive industries have a much better record regarding accidents and mortalities than some older industries, such as construction and mining. However, whereas the technological risks of the past (pit explosions, railway accidents, dam bursts) can now usually be averted, those of today threaten larger areas and for a longer period of time. In the event of a disaster, these areas can no longer be easily isolated and hence evacuated; moreover, toxic emissions (dioxin, radioactive contamination) may have effects that are not detectable for many years or which last for several generations [Lagadec (1981*a*), (1981*b*)].

Of course, the degree of destruction possible is also unprecedented. The cumulative effect of nitrogen oxides on the ozone layer and the problems of fluorinated hydrocarbons, acid rain and the nuclear fuel cycle amply demonstrate that certain technological developments have a transnational, indeed planetary impact. From Seveso to Bhopal and Chernobyl, from oil slicks to the risks of nuclear contamination, from the mercury at Minamata to the fallout from the Bikini explosion, the long-term effects on the environment can combine with a possible effect on the genetic capital of living species – including mankind.

This does not mean that the steps taken to foresee and control possible accidents have lagged far behind this change of scale. In most cases, the huge number of precautions and technical controls matches the immensity and complexity of installations and systems. However, no technological system, no matter how "safe", can escape the unexpected or the fallibility of human intervention. Strikingly, in every major post-war industrial accident, management of the "major technological risk" came up against the same restriction – "human error"; had early indications been heeded, these accidents could have been avoided.

There is also an obvious danger in marketing too soon after too little experimentation, and nowhere is this danger greater than in the area of bio-technology. The case of interferon illustrates the danger of applying new processes without long and rigorous testing to prove therapeutic effectiveness. The hopes raised in the families of cancer victims were commensurate with the eagerness of certain researchers and the first rush of investment from the pharmaceutical industry. But accidents have prompted greater caution in the clinical checking of products – their purity as well as their effectiveness.

Concern even extends to the research process itself. For example, concern over the research on recombinant DNA in the United States has led to directives from the National Institute of Health that seek to control the conditions for research in this area; similar concern prompted recommendations from the Science Foundation, a directive from the European Communities, and the Recommendations of the OECD Council. These regulations prescribe safety precautions intended to obviate potential dangers by controlling physical facilities and biological experiments without restricting research itself. The difficulty lies in striking a balance between the estimated risk of the experiments and the estimated effectiveness of safety precautions [OECD (1986)].

In this case, policy debate focuses on more than innovation applications; society is now involved in controlling basic research, i.e. in making decisions regarding its direction and its very nature. This is enormously significant. If research no longer takes place in isolation, if its controls no longer rest solely with the scientific community, then the direction of scientific progress itself is altered. As in the nuclear debate, it is the possibility of disastrous consequences for the genetic capital that has raised the question of what is an acceptable level of risk. The difference here, however, is that basic research itself – and not just its possible applications – is being called into question.

Once bio-technology moves beyond healing and enters the realm of human engineering, questions of ethics quickly arise and the discussion can even take on a religious dimension. The discovery in molecular biology of the Testis-Determining Factor (TDF) – the gene that determines sex – makes possible the choice of males or females "on demand"; this carries major global consequences for population balance. Cell protein production from substrates and artificial photosynthesis may one day help solve the problems of food shortages and protein deficiences in the Third World; however, these would be accompanied by food produced in the industrialised countries – which would compete with traditional crops grown in the developing countries, and perhaps even jeopardise their continued cultivation [Sasson (1983)]. These are examples of advances that will become subject to legal issues, moral values and social exigencies.

E. R&D POLICY

Since technological innovation is an evolutionary process whose effects are subject to the approval of society at large, governments need to deal with questions relating to the broader societal integration of technological change. Economic considerations alone are no longer sufficient for the complex calculation of social costs and benefits. It is for this reason that a new approach to R&D policy is needed.

From the traditional economic point of view, there is general agreement since Arrow's seminal work that market failure is one of the intrinsic characteristics of R&D and that under-investment will be the logical outcome of market allocation [Arrow (1962)]. This holds true especially in the field of fundamental research, where there are some grounds for continuing concern about under-investment, but also in the field of applied research and development. There are many cases where knowledge is not patentable, or where secrecy is difficult to maintain because of the mobility of scientists and engineers. In such cases one can find plenty of examples of R&D under investment [Nelson (1987)]. On the other hand, imperfect market competition can have the opposite effect of over-investment in R&D. The premium placed on producing inventions and acquiring patents may lead to much duplication of effort, undue haste, and the discarding of promising alternatives [Dasgupta and Stiglitz (1980)].

It has always been tempting to regard market failures as justification for governmental actions to complement, substitute for or guide private R&D effort. Indeed, in practice such failures have led to active government R&D support policies in the science and technology field. However, the fact is that general propositions about where and how market forces malfunction will neither describe experiences accurately nor provide much normative guidance. Big national and international R&D projects planned and financed by the state have thus become some of the most dramatic illustrations of government failure [Nelson (1987)].

The analysis presented here supports the view that R&D policy "should properly focus on problems of dealing with and adjusting to change. It involves in the first instance abandonment of the traditional normative goal of trying to define an optimum and the institutional structure that will achieve it, and an acceptance of the more modest objectives of identifying problems and possible improvements "[Nelson and Winter (1982, p. 366)]. From this perspective, government policy is today at the crossroads. Policies with a near-total focus on R&D that have survived over the last thirty years are in need of having their boundary lines redrawn. The new approach should be broader – not simply based on "market failure" – and involve experimentation with new institutional structures and arrangements.

F. CONSTRUCTIVE TECHNOLOGY ASSESSMENT

A democratic system adjusts to social change and technical innovation while preserving the checks and balances that guarantee its legitimacy. This adjustment is not simply the sum of passive responses; it involves open debate, bargaining and a set of policies that are judged periodically at the ballot-box. Similarly, the regulation of technical change, subject to electoral scrutiny, is the responsibility of government in our societies [Salomon (1981)].

Increasingly, scientific matters are becoming dependent on government support and policies – and so are no longer the researchers' preserve. Science and technology have become both more noticeable because of their repercussions and more open to scrutiny because of the public money invested in them. Public opinion is now more aware of government influence on the direction of national R&D efforts, and of the role government can play in regulating technical change. Just as some national commissions have been set up in certain countries to examine the relation between information technology and privacy, others have been created to discuss the ethical issues of bio-technological research. (For example, in France the mandate of the National Committee on Medical Bio-ethics is "to discuss the major moral problems raised by biological, medical and health research, whether it concerns the individual, specific social categories or society as a whole".)

Governments in most OECD Member countries have taken on the new task of carrying out the research and analysis that is needed for technology assessment in the full sense, and in fact more energetically than has the private sector on its own with only market evaluation and competition as a spur. The aim is not only to foresee the consequences of technical changes without stifling innovation, but also to provide the basic understanding, procedures and institutional mechanisms for regulating the conditions of competition between firms or between countries, taking into account the long-term effects of such changes.

In a period of deregulation, when the aim is to stimulate innovation, cut business costs and lower taxes, it is tempting to equate the notion of less government interference with the legitimising of technological *laissez-faire*. It is true that new or tightened environmental protection, safety and health regulations have altered the pace and direction of innovation in, for example, the chemical and pharmaceutical industries. It is possible that in certain cases the scientific basis of these regulations was weak, and there can be no denying, at least as regards the United States, that the regulatory framework often imposed incoherent and contradictory procedures that led to unexpected delays for industry and, ultimately, to arbitrary decisions [OECD (1980)]. But whatever these excesses (and their dissuasive effect on firms' propensity to innovate cannot be discounted), technological *laissez-faire* would involve still greater disadvantages. Moreover, imposed standards prompt more research that leads to further innovations, as happened in the motor car industry. Cultural necessity is no less the mother of invention than economic necessity: new regulations can sometimes stimulate rather than curb innovation.

It may be said that this is a function of parliaments in democratic societies; certainly technology assessment needs to be set up and conducted in the general framework of parliamentary supervision. The reason for assessment is to provide the public with the necessary information and analysis. Experience has shown that the specialised information needed for such assessment goes beyond that which individuals acting alone can develop; hence, resources – especially institutional support – are required. There are numerous examples of technology assessment, in the United States as well as in Europe, which demonstrate – in spite of variations in institutional form – that this complex type of analysis permits not only better anticipation of the directions of technological change, but also better understanding of its impact on society. Experience shows that parliaments should have adequate structures, resources and access to expert evaluation in order to exercise their responsibilities in this regard.

G. CONCLUSIONS

The idea that society should exercise some control over the consequences of technical change stems from the very successes of the scientific and industrial enterprise, and the costs that these have at times entailed. The issue of government's responsibility as regards regulation of technical change is a thorny one; the criticisms levelled at government intervention tend either not to recognise or to minimise that responsibility. However, if the debate is about policy issues rather than technical matters, government can help answer the key question of whether the cost-benefit share is or is not in the collective interest.

Government should see to it that there are mechanisms ensuring an adequate flow of innovations. An advanced R&D capacity is essential. Moreover, there is the need to move away from the limited view of traditional technology policy, to a more global and social view of innovation management. The risks and costs of making inappropriate choices in regard to the new technologies can be large. The distribution of their costs and benefits can be so uneven as to conflict with the accepted social norms. A society needs to have mechanisms through which it can formulate decisions regarding the nature, acceptability and diffusion of technologies. Technology assessments, both public and private, are one such mechanism.

In brief, long-term growth should be viewed as a process of matching technologies with social needs. Proper matching is the goal towards which the OECD countries must work – together, but with each country proceeding according to its particular historical and cultural characteristics. It is because the pursuit of this goal is possible that the central point of the Report is emphasized: technology policy in the OECD countries can no longer be regarded as an isolated phenomenon, but must be taken into account *in all dimensions* of national and international policy-making. Economic, defence, employment, trade, educational and regional policies are now heavily affected by worldwide developments in technology and their disequilibrating effects. Successful mastery of the technical and social transformations brought about by the information revolution is the key to growth prospects and the future development of our societies.

BIBLIOGRAPHY

ARROW, K. (1962), "Economic Welfare and the Allocation of Resources for Invention", in *The Rate and Direction of Inventive Activity*, National Bureau of Economic Research, Princeton University Press.

BRAUDEL, F. (1979), *Civilisation Matérielle, Economie et Capitalisme*, Vol. 1, *Les Structures du Quotidien*, Paris: Collin.

BROOKS, H. (1973), "Technology Assessment as a Process", UNESCO, *International Social Sciences Journal*, Vol. 25, No. 3, p. 250.

BROOKS, H. (1981), "Science and Technology Policy for the 1980s", *Science, Technology and Society in the 1980s*", OECD, Paris.

DASGUPTA, P. and **STIGLITZ**, J. (1980), "Industrial Structure and the Nature of Innovative Activity", *Economic Journal*, Vol. 90, pp. 266-293.

DONNELLY, J. (1986), *The Confetti Generation*, New York: H. Holt.

FOURASTIE, J. (1979), *Les Trente Glorieuses*, collection Pluriel, Paris: Hachette.

LAGADEC, P. (1981*a*), *La Civilisation du Risque*, Paris: Le Seuil.

LAGADEC, P. (1981*b*), *Le Risque Technologique Majeur*, collection Futuribles, Paris: Pergamon Press.

NELSON, R. (1987), *Understanding Technical Change as an Evolutionary Process*, Amsterdam: North Holland.

NELSON, R. and **WINTER**, S.G. (1982), *An Evolutionary Theory of Economic Change*, Cambridge, Mass.: Harvard University Press.

OECD (1980), *Technical Change and Economic Policy*, Paris.

OECD (1986), *Recombinant DNA Safety Consideration*, Paris.

SALOMON, J.-J. (1981), *Prométhée Empêtré: La Résistance au Changement Technique*, Paris: Pergamon.

SALOMON, J.-J. (1984), "What is Technology? The Issue of Its Origins and Definitions", *History and Technology*, Vol. 1, pp. 113-156.

SALOMON, J.-J. and **LEBEAU**, A. (1988), *L'écrivain Public et l'Ordinateur: Mirages du développement*, Paris: Hachette.

SASSON, A. (1983), *Biotechnologies: Challenges and Promises*, Paris: UNESCO.

WHERE TO OBTAIN OECD PUBLICATIONS
OÙ OBTENIR LES PUBLICATIONS DE L'OCDE

ARGENTINA - ARGENTINE
Carlos Hirsch S.R.L.,
Florida 165, 4° Piso,
(Galeria Guemes) 1333 Buenos Aires
Tel. 33.1787.2391 y 30.7122

AUSTRALIA - AUSTRALIE
D.A. Book (Aust.) Pty. Ltd.
11-13 Station Street (P.O. Box 163)
Mitcham, Vic. 3132 Tel. (03) 873 4411

AUSTRIA - AUTRICHE
OECD Publications and Information Centre,
4 Simrockstrasse,
5300 Bonn (Germany) Tel. (0228) 21.60.45

Gerold & Co., Graben 31, Wien 1 Tel. 52.22.35

BELGIUM - BELGIQUE
Jean de Lannoy,
Avenue du Roi 202
B-1060 Bruxelles Tel. (02) 538.51.69

CANADA
Renouf Publishing Company Ltd/
Éditions Renouf Ltée,
1294 Algoma Road, Ottawa, Ont. K1B 3W8
Tel: (613) 741-4333

Toll Free/Sans Frais:
Ontario, Quebec, Maritimes:
1-800-267-1805
Western Canada, Newfoundland:
1-800-267-1826
Stores/Magasins:
61 rue Sparks St., Ottawa, Ont. K1P 5A6
Tel: (613) 238-8985
211 rue Yonge St., Toronto, Ont. M5B 1M4
Tel. (416) 363-3171

Federal Publications Inc.,
301-303 King St. W.,
Toronto, Ont. M5V 1J5
Tel. (416)581-1552

Les Éditions la Liberté inc.,
3020 Chemin Sainte-Foy,
Sainte-Foy, P.Q. G1X 3V6,
Tel. (418)658-3763

DENMARK - DANEMARK
Munksgaard Export and Subscription Service
35, Nørre Søgade, DK-1370 København K
Tel. +45.1.12.85.70

FINLAND - FINLANDE
Akateeminen Kirjakauppa,
Keskuskatu 1, 00100 Helsinki 10 Tel. 0.12141

FRANCE
OCDE/OECD
Mail Orders/Commandes par correspondance :
2, rue André-Pascal,
75775 Paris Cedex 16
Tel. (1) 45.24.82.00

Bookshop/Librairie : 33, rue Octave-Feuillet
75016 Paris
Tel. (1) 45.24.81.67 or/ou (1) 45.24.81.81

Librairie de l'Université,
12a, rue Nazareth,
13602 Aix-en-Provence Tel. 42.26.18.08

GERMANY - ALLEMAGNE
OECD Publications and Information Centre,
4 Simrockstrasse,
5300 Bonn Tel. (0228) 21.60.45

GREECE - GRÈCE
Librairie Kauffmann,
28, rue du Stade, 105 64 Athens Tel. 322.21.60

HONG KONG
Government Information Services,
Publications (Sales) Office,
Information Services Department
No. 1, Battery Path, Central

ICELAND - ISLANDE
Snæbjörn Jónsson & Co., h.f.,
Hafnarstræti 4 & 9,
P.O.B. 1131 – Reykjavik
Tel. 13133/14281/11936

INDIA - INDE
Oxford Book and Stationery Co.,
Scindia House, New Delhi 110001
Tel. 331.5896/5308
17 Park St., Calcutta 700016 Tel. 240832

INDONESIA - INDONÉSIE
Pdii-Lipi, P.O. Box 3065/JKT.Jakarta
Tel. 583467

IRELAND - IRLANDE
TDC Publishers - Library Suppliers,
12 North Frederick Street, Dublin 1
Tel. 744835-749677

ITALY - ITALIE
Libreria Commissionaria Sansoni,
Via Lamarmora 45, 50121 Firenze
Tel. 579751/584468
Via Bartolini 29, 20155 Milano Tel. 365083
La diffusione delle pubblicazioni OCSE viene
assicurata dalle principali librerie ed anche da :
Editrice e Libreria Herder,
Piazza Montecitorio 120, 00186 Roma
Tel. 6794628

Libreria Hœpli,
Via Hœpli 5, 20121 Milano Tel. 865446
Libreria Scientifica
Dott. Lucio de Biasio "Aeiou"
Via Meravigli 16, 20123 Milano Tel. 807679

JAPAN - JAPON
OECD Publications and Information Centre,
Landic Akasaka Bldg., 2-3-4 Akasaka,
Minato-ku, Tokyo 107 Tel. 586.2016

KOREA - CORÉE
Kyobo Book Centre Co. Ltd.
P.O.Box: Kwang Hwa Moon 1658,
Seoul Tel. (REP) 730.78.91

LEBANON - LIBAN
Documenta Scientifica/Redico,
Edison Building, Bliss St.,
P.O.B. 5641, Beirut Tel. 354429-344425

MALAYSIA/SINGAPORE - MALAISIE/SINGAPOUR
University of Malaya Co-operative Bookshop
Ltd.,
7 Lrg 51A/227A, Petaling Jaya
Malaysia Tel. 7565000/7565425
Information Publications Pte Ltd
Pei-Fu Industrial Building,
24 New Industrial Road No. 02-06
Singapore 1953 Tel. 2831786, 2831798

NETHERLANDS - PAYS-BAS
SDU Uitgeverij
Christoffel Plantijnstraat 2
Postbus 20014
2500 EA's-Gravenhage Tel. 070-789911
Voor bestellingen: Tel. 070-789880

NEW ZEALAND - NOUVELLE-ZÉLANDE
Government Printing Office Bookshops:
Auckland: Retail Bookshop, 25 Rutland Stseet,
Mail Orders, 85 Beach Road
Private Bag C.P.O.
Hamilton: Retail: Ward Street,
Mail Orders, P.O. Box 857
Wellington: Retail, Mulgrave Street, (Head
Office)
Cubacade World Trade Centre,
Mail Orders, Private Bag
Christchurch: Retail, 159 Hereford Street,
Mail Orders, Private Bag
Dunedin: Retail, Princes Street,
Mail Orders, P.O. Box 1104

NORWAY - NORVÈGE
Narvesen Info Center – NIC,
Bertrand Narvesens vei 2,
P.O.B. 6125 Etterstad, 0602 Oslo 6
Tel. (02) 67.83.10, (02) 68.40.20

PAKISTAN
Mirza Book Agency
65 Shahrah Quaid-E-Azam, Lahore 3 Tel. 66839

PHILIPPINES
I.J. Sagun Enterprises, Inc.
P.O. Box 4322 CPO Manila
Tel. 695-1946, 922-9495

PORTUGAL
Livraria Portugal,
Rua do Carmo 70-74,
1117 Lisboa Codex Tel. 360582/3

SINGAPORE/MALAYSIA - SINGAPOUR/MALAISIE
See "Malaysia/Singapor". Voir
« Malaisie/Singapour »

SPAIN - ESPAGNE
Mundi-Prensa Libros, S.A.,
Castelló 37, Apartado 1223, Madrid-28001
Tel. 431.33.99
Libreria Bosch, Ronda Universidad 11,
Barcelona 7 Tel. 317.53.08/317.53.58

SWEDEN - SUÈDE
AB CE Fritzes Kungl. Hovbokhandel,
Box 16356, S 103 27 STH,
Regeringsgatan 12,
DS Stockholm Tel. (08) 23.89.00
Subscription Agency/Abonnements:
Wennergren-Williams AB,
Box 30004, S104 25 Stockholm Tel. (08)54.12.00

SWITZERLAND - SUISSE
OECD Publications and Information Centre,
4 Simrockstrasse,
5300 Bonn (Germany) Tel. (0228) 21.60.45

Librairie Payot,
6 rue Grenus, 1211 Genève 11
Tel. (022) 31.89.50

United Nations Bookshop/Librairie des Nations-Unies
Palais des Nations,
1211 – Geneva 10
Tel. 022-34-60-11 (ext. 48 72)

TAIWAN - FORMOSE
Good Faith Worldwide Int'l Co., Ltd.
9th floor, No. 118, Sec.2
Chung Hsiao E. Road
Taipei Tel. 391.7396/391.7397

THAILAND - THAILANDE
Suksit Siam Co., Ltd., 1715 Rama IV Rd.,
Samyam Bangkok 5 Tel. 2511630
INDEX Book Promotion & Service Ltd.
59/6 Soi Lang Suan, Ploenchit Road
Patjumamwan, Bangkok 10500
Tel. 250-1919, 252-1066

TURKEY - TURQUIE
Kultur Yayinlari Is-Turk Ltd. Sti.
Ataturk Bulvari No: 191/Kat. 21
Kavaklidere/Ankara Tel. 25.07.60
Dolmabahce Cad. No: 29
Besiktas/Istanbul Tel. 160.71.88

UNITED KINGDOM - ROYAUME-UNI
H.M. Stationery Office,
Postal orders only: (01)211-5656
P.O.B. 276, London SW8 5DT
Telephone orders: (01) 622.3316, or
Personal callers:
49 High Holborn, London WC1V 6HB
Branches at: Belfast, Birmingham,
Bristol, Edinburgh, Manchester

UNITED STATES - ÉTATS-UNIS
OECD Publications and Information Centre,
2001 L Street, N.W., Suite 700,
Washington, D.C. 20036 - 4095
Tel. (202) 785.6323

VENEZUELA
Libreria del Este,
Avda F. Miranda 52, Aptdo. 60337,
Edificio Galipan, Caracas 106
Tel. 951.17.05/951.23.07/951.12.97

YUGOSLAVIA - YOUGOSLAVIE
Jugoslovenska Knjiga, Knez Mihajlova 2,
P.O.B. 36, Beograd Tel. 621.992

Orders and inquiries from countries where Distributors have not yet been appointed should be sent to:
OECD, Publications Service, 2, rue André-Pascal,
75775 PARIS CEDEX 16.

Les commandes provenant de pays où l'OCDE n'a pas encore désigné de distributeur doivent être adressées à :
OCDE, Service des Publications, 2, rue André-Pascal, 75775 PARIS CEDEX 16.

71784-07-1988

OECD PUBLICATIONS, 2, rue André-Pascal, 75775 PARIS CEDEX 16 - No. 44633 1988
PRINTED IN FRANCE
(81 88 07 1) ISBN 92-64-13180-9

This Report discusses the means to enhance economic and social progress offered by the new technologies within the context of the increasingly interdependent nature of the global economy. It argues that technological change is a social process: the potential benefits can be fully exploited only if technical change is accompanied by appropriate structural and institutional reforms. The Report makes recommendations for such reforms pertaining to the areas of enterprise, education and training, investment, international and regional transfer of technology, and R&D and technology assessment policies.

(81 88 07 1) ISBN 92-64-13180-9 FF 90